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# The trouble with *Neophyllis pachyphylla* (lichenised Ascomycetes)

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**Abstract:** The genus *Neophyllis* F.Wilson in Australia is considered to comprise two morphologically and chemically distinct species, *N. pachyphylla* (Müll.Arg.) Gotth.Schneid. and *N. melacarpa* (F.Wilson) F.Wilson. The confusion surrounding the application of the former name is clarified and revised descriptions of both are presented.

**Keywords:** Australia, grayanic acid, lichens, melacarpic acid, New Zealand, Tasmania

## Introduction

The genus *Neophyllis* F.Wilson (Sphaerophoraceae) is a distinctly Australasian taxon with two described species, *N. melacarpa* (F.Wilson) F.Wilson and *N. pachyphylla* (Müll.Arg.) Gotth.Schneid. The former is generally well-known to lichenologists, being widespread on the south-eastern Australian mainland, in Tasmania and in New Zealand. It is commonly seen on rotting wood where it forms extensive colonies of greenish or olive-coloured, often digitate squamules bearing black, globose apothecia. *Neophyllis pachyphylla*, on the other hand, is rarely seen, collected or mentioned in inventories. In his *Flora of Australia* account, Filson (1992) cited collections from Mt William (Victoria) and Pigeon House Mountain (N.S.W.) and little data have been added since that time. This paper addresses some of the complexities surrounding the application of this name and provides revised descriptions of both species.

## Material and methods

The study is based on the extensive collections of *Neophyllis*, compiled mostly by the author and housed in the Tasmanian Herbarium (HO); these are chiefly from Tasmania and the Australian mainland, with a small number from New Zealand. Examination of thallus and apothecial anatomy was undertaken on hand-cut sections mounted in water, 10% KOH (K), 50% $HNO_3$ (N), and in Lugols Iodine after pre-treatment in K and rinsing with water (KI). Measurements of ascospores are based on at least 50 observations per taxon and are presented in the format 5$^{th}$ percentile–*average*–95$^{th}$ percentile, with outlying values in brackets. Routine chemical analysis was undertaken using standard methods of thin-layer chromatography (TLC), with solvent A as the preferred medium (Orange *et al.* 2010).

## History

*Neophyllis melacarpa* was described by Wilson (1889), originally in the genus *Phyllis*. As this is a genus of the Angiosperm family Rubiaceae, he soon redescribed it within a new genus, *Neophyllis* (Wilson 1891). At the time of description, Wilson perceived affinities to the genus *Cladonia*, and the species remained classified in Cladoniaceae, even as it was transferred to *Phyllopsora* (Müller 1895), *Gymnoderma* (Yoshimura 1973) and eventually back to *Neophyllis* (Schneider 1979); see also Jahns (1970) and Wei & Ahti (2002). It was not until Döring *et al.* (1999) and Döring & Wedin (2000) investigated the ontogeny of the genus that it, together with another Australasian endemic genus, *Austropeltum* Henssen, Döring & Kantvilas, was transferred to Sphaerophoraceae. This classification was also confirmed by molecular methods (Wedin & Döring 1999).

The other species of the genus, *N. pachyphylla*, was originally described by Müller (1887) in the genus *Psora*, and transferred to *Neophyllis* by Schneider (1979). Schneider characterised *N. melacarpa* by its forked, digitate squamules with rounded apices and a corticolous habitat, and *N. pachyphylla* was distinguished from it by having sparsely branched, crowded squamules with flattened apices and a terricolous habitat. He also mentioned the medulla of the latter being brown, but this is almost certainly due to the single specimen that he saw (the type) being in very poor condition. Müller (1895) had also compared the two species, claiming, *inter alia*, that the ascospores of *N. melacarpa* were narrower. Subsequently Filson (1992) again distinguished the species in a similar way, but added the additional and critical observation of a chemical difference, namely that *N. pachyphylla* contained melacarpic acid only, whereas *N. melacarpa* contained grayanic acid plus fumarprotocetraric and melacarpic acids.

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## Present observations

### *Generic features*

Critical features of the genus *Neophyllis* include: the squamulose to minutely coralloid-fruticose thallus with black, globose, immarginate apothecia (Fig. 1); the green photobiont with globose cells 7–11 µm diam.; the particular, 8-spored asci ("*Neophyllis*-type") with an amyloid tholus penetrated by a darker-staining tube-structure and lacking an ocular chamber; the relatively robust, parallel paraphyses with few branches and anastomoses; and the simple, ellipsoid, non-halonate, hyaline ascospores (Fig. 2). The conidiomata are reported by Döring *et al.* (1999) as being laminal, subglobose pycnidia with bacilliform conidia, but none were observed in the present study.

### *Chemistry*

Thallus chemistry in *Neophyllis* is dominated by the dibenzofuranes, grayanic and/or melacarpic acids, and is a critical taxonomic character. In the course of the present study, scores of specimens were examined by TLC, confirming that grayanic acid is always present in *N. melacarpa*. This substance appears about half-way up TLC plates as a UV+ pale blue spot before heating, and as a pale pinkish brown, UV+ purple spot after acid spray and heating. Additional melacarpic acid is commonly present as a major or minor compound, and fumarprotocetraric acid (a slow grey spot) may also be present in minor concentrations. In contrast, *N. pachyphylla* always contains melacarpic acid as the sole major compound. This substance appears on TLC plates as a UV+ pale blue spot before heating, and as a pale blue-grey, UV+ purple spot after heating; it is faster than grayanic acid in all standard solvents.

### *Morphology*

*Neophyllis melacarpa* is a highly variable species. On wood, it forms loose aggregations of apically divided squamules, with the ultimate segments being terete and coralloid (Fig. 1A). With increasing exposure, the squamules become ever more densely packed together, more erect and form swards and cushions (Fig. 1B). In extreme cases, the thallus consists entirely of ± erect, terete lobes (Fig. 1C). Whilst the two extreme forms look very different from each other, a continuum exists between the ascending squamulose and erect teretiform morphologies.

The morphological criteria by which Schneider (1979) and Filson (1992) delimited *N. pachyphylla* fall within the range of variation displayed by *N. melacarpa*. The two species also overlap ecologically, in that *N. melacarpa* can grow on soil as well as wood. Moreover, at every locality where *N. pachyphylla* has been observed during the present study, *N. melacarpa* is also present. However, at these locations, *N. melacarpa* is usually common, whereas *N. pachyphylla* is typically rare. Chemically, however, *N. pachyphylla* is distinct in never containing grayanic acid (which is always present in *N. melacarpa*) and always containing melacarpic acid (which is only sometimes present in *N. melacarpa*). Thus, to distinguish the two species ecologically is untenable, but to do so chemically is unequivocal, although this requires TLC.

In the course of the present work, it was found that the two species can be readily distinguished morphologically. The squamules of *Neophyllis pachyphylla* tend to be more dispersed (Fig. 1D) and, whereas terete segments are often developed, they do not dominate the thallus (Figs 1E–F). When forming extensive thalli, *N. pachyphylla* is particularly distinctive, with the squamules being rather tongue-like and having slightly thickened, rounded apices (Fig. 3). This observation was tested in the field when the author collected and chemically analysed multiple specimens of both taxa and was always able to identify them correctly on morphology alone.

### *The status of* N. pachyphylla

An argument has been made in the past for considering *N. pachyphylla* as simply a chemical variant of *N. melacarpa*. This was suggested in the literature (Döring *et al.* 1999; Wei & Ahti 2002), and the type specimen of *N. pachyphylla* (in G) was annotated to that effect by the American lichenologist Paula de Priest in 1999. However, the nomenclatural situation is complicated by *N. pachyphylla* being the older name, as also noted by Döring *et al.* (1999) and Wei & Ahti (2002). Synonymisation would necessitate the adoption of a rarely used name of what had been regarded as an extremely rare taxon, for a species with a currently widely used name that is applied to an extremely common lichen. Alternatively, a case for conservation of *N. melacarpa* would need to be made. The conclusion of the present study, however, is that in addition to their chemical difference, the two taxa also differ morphologically, and should be maintained as separate.

### Key to the species of *Neophyllis*

**1.** Grayanic acid present, frequently with additional melacarpic and/or fumarprotocetraric acids; thallus forming dense swards or cushions, composed of apically divided squamules with the ultimate segments terete and coralloid, or with the thallus consisting entirely of terete lobes; common on wood, but also found on moist peaty or sandy soil. . . . . ***N. melacarpa***

**1:** Melacarpic acid present as the sole major compound; thallus composed of usually rather dispersed, ascending squamules with slightly thickened, rounded apices; terete projections often present but not dominating the thallus; rare on coarse, sandy or gravelly soil over granite, or directly on rock; not observed on wood. . . . . ***N. pachyphylla***

## Taxonomy

### *Neophyllis melacarpa* (F.Wilson) F.Wilson

*J. Linn. Soc., Bot.* 28: 372 (1891). — *Phyllis melacarpa* F.Wilson, *Victorian Naturalist* 6: 68 (1891). — *Gymnoderma melacarpum* (F.Wilson) Yoshim., *J. Jap. Bot.* 48: 287 (1973). — **Type citation:** "Habitat supra truncos arborum permagnorum viventes atque putridos in regionibus montanis, Warburton et Mt Macedon." — **Lectotype:** Victoria: Black Spur, on dead bark of large eucalyptus, Feb, 1888, *F.R.M. Wilson s.n.* (NSW 423991!), *fide* Filson, *Austral. Fl. Fauna Ser.* 4: 231 (1986), as "Holotype". **Isolectotype:** G00292739 (ex Herb. Müll.Arg.). **Residual syntypes:** G00293378, G00292381 (see below).

*Psora dactylophylla* Müll.Arg., *Bull. Herb. Boissier* 1: 35 (1893). — *Lecidea dactylophylla* (Müll. Arg.) Zahlbr., *Cat. Lich. Univ.* 3: 867 (1925). — *Phyllopsora melanocarpa* Müll.Arg., *Hedwigia* 34: 28 (1895), *nom. superfl. & illeg.* (based on the same type). — **Type citation:** "Ad ligna emortua, Mt Macdon : Wilson, n. 150." — **Lectotype (here designated):** On decaying log, Mt Macedon, Victoria, *F.R.M. Wilson 150* (G00292381, ex Herb. Müll.Arg., annotated "L.[ichenes] Wils.[onianae] n. 15."). **Isolectotype:** G00293378 (ex Herb. Müll.Arg., annotated "L.[ichenes] Exot.[ici] n. 109."). **Mycobank typification number: MBT10005953.**

Thallus squamulose to diminutively coralloid-fruticose, forming extensively spreading colonies or contiguous tufts, swards or cushions 5–40 mm wide. Squamules bright green to olive when fresh and moist, drying to a yellowish green to olive brownish, glossy, commonly dorsiventrally flattened at the base, with a pale lower surface, ascending or decumbent, to 15 mm long, 0.3–0.6 (–1) mm wide, pinnately or digitately branched, with the ultimate segments terete, very fragile and brittle, to c. 0.15 mm wide, sometimes segmented by slight constrictions, or with the terete segments arising directly from the upper surface of the squamules, less frequently with all parts entirely coralloid-terete, erect, 5–10 mm tall, to 0.3 (–0.5) mm wide, sparsely branched and entangled in mats or cushions. Apothecia to 1 (–1.4) mm wide, subsessile and nestling amongst the squamules or elevated above the thallus on terete stalks to c. 3 mm tall. Proper exciple in section hyaline within, at the outer edge dark brown, K± unchanged, N+ reddish, soon reflexed and ± excluded, composed of radiating, anastomosing hyphae in a gel matrix. Hypothecium massive, diffusely brown to hyaline. Hymenium hyaline, not inspersed, 50–70 µm thick, overlain by a dark chocolate-brown epithecium c. 10 µm thick, ± unchanged in K, N+ red. Asci 40–50 × 10–15 µm. Paraphyses 2–3 µm thick, with the apices sometimes capitate and brown, 3 (–5) µm wide. Ascospores (8–) 9–*10.9*–12.5 (–13) × 4–*4.8*–6 µm. Conidiomata not seen. Chemistry: grayanic acid, melacarpic acid (±), fumarprotocetraric acid (±), plus biosynthetically related compounds such as congrayanic acid or 4-*O*-demethylgrayanic acid in trace amounts only; medulla K–, KC–, C–, P– or + yellowish to orange-red, UV+ white. **Figs 1A–C.**

***Typification.*** Type material is present in both the Conservatoire et Jardin botaniques de la Ville de Genève (G), and the National Herbarium of New South Wales (NSW). Filson (1986) referred to the latter specimen as the holotype, although in doing so he inadvertently selected it as the lectotype, here corrected under Art. 9.10. A putative isolectotype cited by Filson (1992) as being in BM was not located.

***Remarks.*** *Neophyllis melacarpa* is common and widespread in south-eastern Australia, Tasmania and New Zealand. Although it occurs mainly on wood, it can also colonise peaty or sandy soil. In Tasmania, it occurs in a wide range of rainforest, sclerophyll forest, woodland and heathland vegetation communities.

In shaded forest situations, this species is mostly found on wood, especially rotting logs, buttresses and stumps of old eucalypts. It also colonises mature trunks of other trees which produce a similarly soft, moisture-retaining substratum, such as *Nothofagus* and *Athrotaxis*. In these situations, the thallus is usually bright green (when fresh), composed of ascending or decumbent, dorsiventral, ± pinnately branched squamules, and forms extensive, spreading swards, potentially covering up to several square metres, often intermixed with *Cladia aggregata* (Sw.) Nyl. and *Cladonia rigida* (Hook.f. & Taylor) Hampe. The coralloid extensions of the squamules may be scattered or very abundant to the extent of dominating the entire thallus, even within the same colony. In more exposed, sunny situations, the species is found mainly on soil. Here the thallus tends to comprise a dense cushion of erect, terete, coralloid lobes. This form is particularly common in high rainfall areas of the west and south-west of Tasmania, where it is found on soil in crevices of quartzitic boulders, or on the ground in buttongrass (*Gymnoschoenus sphaerocephalus*)-dominated moorland or in alpine or subalpine heathland. Such caespitose, terricolous forms are also seen in lower rainfall areas on coastal granite pinnacles in eastern Tasmania, on Triassic sandstone in south-eastern Tasmania, and on the coarse sandstones of the New South Wales Tablelands.

### *Selected specimens examined*

**AUSTRALIA.** NEW SOUTH WALES. Braidwood district, S of Rossi, 19.xii.1967, *W.A. Weber & D. McVean* (*Lich. Exsicc. Colo. 246*) (HO); track to Wentworth Falls, 34°44'S 150°22'E, 820 m, 2.x.1999, *R.G. Coveney 18075 & M. Sherring* (HO, NSW); Pigeon House Mountain, 35°21'S 150°16'E, 700 m, 21.x.1999, *G. Kantvilas 348/99* (HO).

AUSTRALIAN CAPITAL TERRITORY. Tidbinbilla N.R., tributary of Hurdle Ck, 35°25'S 148°54'E, 1000 m, 26.i.1995, *N. Williams 7* (CANB, HO).

VICTORIA. Bonang Hwy near Tigaringa Track, 37°05'S 148°46'E, 890 m, 26.ix.1985, *J.A. Curnow 383* (CANB, HO); Bulga N.P., Lyrebird-Ash Tracks, 38°26'S 146°34'E, 500 m, 14.iv.1993, *J.A. Elix 29763* (CANB, HO).

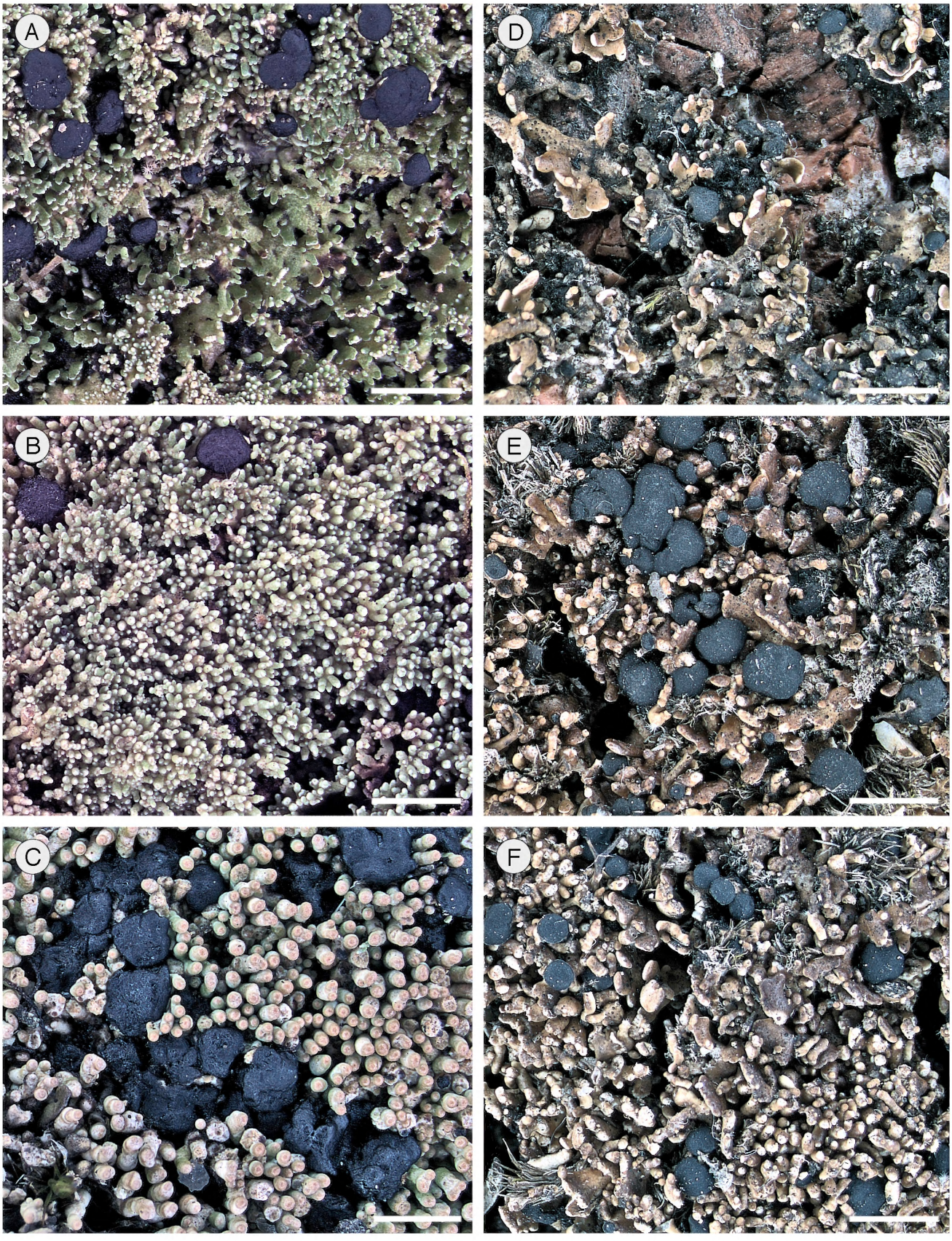


**Fig. 1.** Morphological variation in *Neophyllis*. **A–C** *N. melacarpa*: **A** Growing on rotting wood: squamulose thallus developing coralloid, finger-like projections; **B** thallus dominated by coralloid projections (different section of same colony); **C** on soil: robust thallus consisting entirely of erect, terete, coralloid lobes. **D–F** *N. pachyphylla*: **D** Growing on soil: thallus of dispersed squamules with ± rounded, intact apices; **E** on soil: thallus dominated by squamules with ± rounded apices and occasional coralloid-terete projections; **F** thallus of ascending squamules. Scale = 2 mm. — A, B *G. Kantvilas 336/21*, C *GK 337/21*, D *GK 189/05*, E, F *GK 41/95*. Photos: J. Jarman.

TASMANIA. Flinders Island, Mt Strzelecki, 40°12'S 148°05'E, 710 m, 21.i.2006, *G. Kantvilas 41/06* (HO); Guy Fawkes Rivulet, 42°54'S 147°17'E, x.1912, *L. Rodway s.n.* (HO); Mt Wellington, 42°53'S 147°15'E, iii.1963, *P.W. James s.n.* (BM, HO); St Columba Falls, 41°20'S 147°55'E, 300 m, 10.x.1968, *G.C. Bratt 68/1307* (HO); Five Road, Florentine Valley, 42°43'S 146°26'E, 450 m, 1.v.1981, *G. Kantvilas 259/81* (BG, BM, HO); Grasstree Hill, 42°47'S 147°21'E, 400 m, 14.viii.1981, *G. Kantvilas 710/81 & P. James* (BM, HO); Strathgordon Road, near Boyd River, 400 m, 29.ii.1984, *G. Kantvilas 493/84* (*A. Vězda: Lich. Sel. Exsicc.* 2020) (HO); Perambulator Ridge, 42°31'S 146°11'E, 7.ii.1985, *G. Kantvilas 50/85* (HO); Yarlington Tier, 42°32'S 147°18'E, 620 m, 30.xi.1988, *G. Kantvilas 588/88* (HO); Denison Road, 43°00'S 146°50'E, 60 m, 24.vii.2002, *G. Kantvilas 388/02* (HO); Alum Cliffs, 41°32'S 146°26'E, 350 m, 13.viii.2005, *G. Kantvilas 234/05* (HO); Windsong Property, Callitris Gully, 42°21'S 147°55'E, 40 m, 26.x.2017, *G. Kantvilas 354/17* (HO); Hungry Flats Road, 42°32'S 147°27'E, 230 m, 17.viii.2021, *G. Kantvilas 336/21* (H, HO, NY, UPS); Hungry Flats, 540 m, 17.viii.2021, *G. Kantvilas 337/21* (HO).

**NEW ZEALAND.** SOUTH ISLAND. Arthurs Pass, 42°55'S 171°30'E, 11.xi.1972, *G.C. Bratt 72/1814* (HO); Cobb Valley, track to Mt Mytton, 41°07'S 172°35'E, 1060 m, 21.ii.1989, *A.J. Fife 9184* (CHR, HO); Westport, Denniston Plateau, Mt Rochfort, 750 m, 21.iv.1997, *W. Malcolm & A. Vězda* (*A. Vězda: Lich. Rariores Exsicc.* 380) (HO).

### ***Neophyllis pachyphylla*** (Müll.Arg.) Gotth.Schneid.

*Biblioth. Lichenol.* 13: 168 (1980) [1979]. — *Psora pachyphylla* Müll.Arg., *Flora* 70: 319 (1887). — *Lecidea pachyphylla* (Müll.Arg.) Zahlbr., *Cat. Lich. Univers.* 3: 888 (1925). — **Holotype:** Australia, Victoria, Mt William, 5000' [1500 m], Oct. 1882, *Dr Sullivan 86* (G00292738!, ex Herb. Müll.Arg., annotated "L.[ichenologische] B.[eiträge] n. 1155").

Thallus small-squamulose, forming spreading colonies. Squamules olive-green to brownish, glossy, 1–4 mm long, 0.2–0.6 mm wide, dorsiventrally flattened, with a pale lower surface, ascending or, more rarely, decumbent, sparsely to occasionally branched, with the apices remaining flattened, a little thickened and tongue-like, or developing terete, ± erect segments 0.2–0.3 (–0.5) mm wide, dispersed or crowded together in mats. Apothecia to 1.5 (–1.7) mm wide, subsessile and nestling amongst the squamules. Proper exciple in section hyaline within, at the outer edge dark brown, K± unchanged, N+ reddish, soon reflexed and ± excluded, composed of radiating, anastomosing hyphae in a gel matrix. Hypothecium massive, diffusely brown to hyaline, typically darkest and with additional dilute greenish, K+ intensifying, N+ red pigment in the upper part. Hymenium hyaline, not inspersed, 55–65 µm thick, overlain by a dark chocolate-brown epithecium c. 10 µm thick, ± unchanged in K, N+ reddish. Asci 35–55 × 12–15 µm. Paraphyses 2–3 µm thick, with apices sometimes capitate and brown, 3 (–5) µm wide. Ascospores 9–*11.2*–13.5 (–14) × 4.5–*5.2*–6 (–6.5) µm. Conidiomata not seen. Chemistry: melacarpic acid; medulla K–, KC–, C–, P–, UV± whitish. **Figs 1D–F, 2, 3.**

***Remarks.*** The description is based on Australian and Tasmanian specimens that contain melacarpic acid as the sole major metabolite. In general, *Neophyllis pachyphylla* is a more robust species, with thicker squamules that remain largely dispersed and do not form caespitose clumps (Fig. 3). With their slightly thickened, rounded apices, the ascending squamules sometimes resemble tiny tongues. Terete projections are sometimes formed on the squamules, but they do not dominate the thallus, nor are they as brittle as in *N. melacarpa*. After examining large numbers of herbarium specimens representing both species, and studying the species in the field, the conclusion is that one is highly unlikely to ever mistake *N. melacarpa* for *N. pachyphylla*. When the two species grow together, for example on soil, they are also unlikely to be confused, as the former is more delicate, brittle and often caespitose. However, it is strongly recommended that any inferred specimens of *N. pachyphylla* be checked chemically. The putative spore size difference (Müller 1895) was not supported in the present study. The additional, subhymenial greenish pigment observed in *N. pachyphylla* is likely to be environmentally induced and not of taxonomic significance.

On this basis, *N. pachyphylla* is known from the type locality in the Grampians, Victoria, from parts of eastern Tasmania, and from the southern tablelands of New South Wales. At the Tasmanian and N.S.W. localities, *N. melacarpa* is also present. Specimens in HO from Pigeon House Mountain contain grayanic acid and are identified as *N. melacarpa*, although *N. pachyphylla* has been recorded from there (Filson 1992). The species

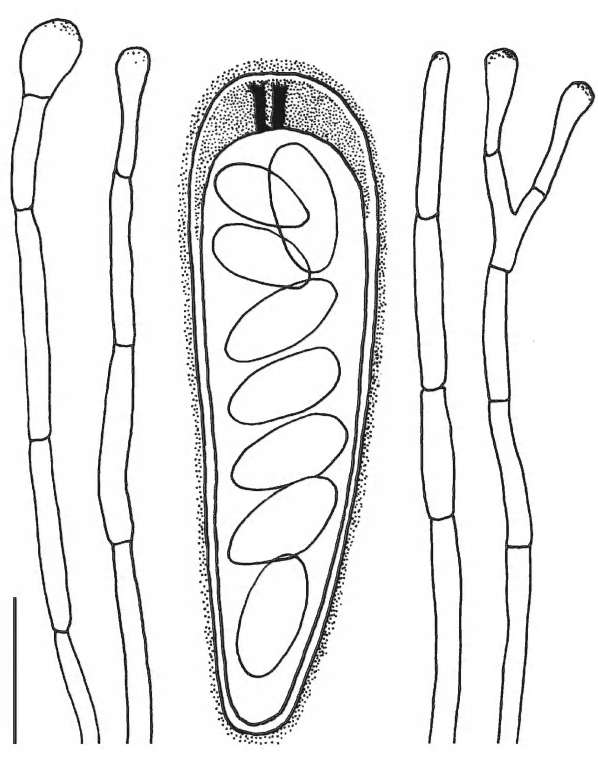

**Fig. 2.** *Neophyllis pachyphylla* anatomy, showing the "*Neophyllis*-type" ascus (with amyloid parts stippled), paraphyses and ascospores. Scale = 10 µm.

**Fig. 3.** *Neophyllis pachyphylla* habit on granite (Mt Stronach, Tasmania). Photo J. Jarman.

occurs directly on rock (Devonian granite in Tasmania) or on coarse sandy or gravelly soil over granite or sandstone (in N.S.W.) in open sclerophyll woodland. All specimens collected by the author were from shaded rocks subject to moisture seepage, or to accumulations of silt in drainage channels on large rock outcrops.

Specimens containing melacarpic acid only are also known from New Zealand although the detailed ecology of their provenance is unknown. Whilst these could be included under *N. pachyphylla* on chemical characters alone, they are likely to represent a further, undescribed species of the genus. They consist of erect well-separated terete lobes, up to 7 mm tall and 0.4–1 mm wide; no flattened squamules are evident in what are rather small, fragmented specimens.

### *Specimens examined*

**AUSTRALIA.** NEW SOUTH WALES. Braidwood Road, c. 5 km NE of Nerriga, 35°05'S 150°08'E, 17.xi.2012, *G. Kantvilas 625/12* (HO); Bulee Gap, 8 km N of Nerriga, 35°05'S 150°08'E, 690 m, 18.iv.2014, *G. Kantvilas 382/14* (HO).

TASMANIA. Mt Cameron, 40°59'S 147°56'E, 550 m, 5.vii.1995, *G. Kantvilas 41/95* (HO); The Hazards, near the Wineglass Bay Lookout, 42°09'S 148°17'E, 180 m, 19.vii.2005, *G. Kantvilas 188/05, 189/05, 190/05 & J. Jarman* (HO); northern ridge of Mt Stronach, 41°10'S 147°34'E, 400 m, 11.ix.2021, *G. Kantvilas 360/21* (HO).

### *New Zealand specimens examined, currently identified as* **Neophyllis pachyphylla**

**NEW ZEALAND.** SOUTH ISLAND. Stockton Plateau, above Granity, 41°38'S 171°54'E, 16.ii.1986, *A.M. Buchanan 13086* (HO); Westport, Denniston Plateau, 670 m, 12.iii.2009, *W. Malcolm s.n.* (HO); Denniston, near road to old Escarpment Mine, 645 m, 10.xii.2013, *D. Glenny 12028* (CHR, HO).

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# Confirming the presence of some introduced Russulaceae species in Australia and New Zealand

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**Abstract:** To aid the identification of Russulaceae associated with non-native introduced trees in urban areas, botanical gardens, and plantation forestry we sequenced selected material in the fungaria of AD & MEL (Australia) and PDD (New Zealand). Phylogenetic analysis and morphology support the presence of 13 species: *Lactarius deliciosus* (L.) Gray, *L. glyciosmus* (Fr.) Fr., *L. pubescens* Fr., *L. pyrogalus* (Bull.) Fr., *L. quietus* (Fr.) Fr., *L. rufus* (Scop.) Fr., *L. turpis* (Weinm.) Fr., *Russula amoenolens* Romagn., *R. cessans* A.Pearson, *R. ionochlora* Romagn., *R. laccata* Huijsman, *R. nitida* (Pers.) Fr., and *R. praetervisa* Sarnari. The species are found in association with various introduced gymnosperm and angiosperm ectomycorrhizal trees, and the fungi all appear to be of European origin. We provide brief descriptions, images and briefly discuss their origins and ecology.

**Keywords:** Russulaceae, introductions, naturalised, New Zealand, Australia

## Introduction

The family Russulaceae is one of the larger groups of ectomycorrhizal fungi. Species in the Russulaceae are often large, colourful and noticeable, but they are not always easy to identify.

New Zealand and Australia have many indigenous species in the family, with only a small proportion formally described. These species are frequent in natural habitats and in association with native trees and shrubs in several indigenous plant families, primarily Myrtaceae, Nothofagaceae and Fabaceae (Field *et al.* 2015; Tedersoo & Brundrett 2017; Brundrett & Tedersoo 2018). There has been a historical trend of adopting the names of similar-looking taxa from the northern hemisphere. However, characterisation using modern sequence-based methods always demonstrates these species are different from those found in the northern hemisphere. For example, the native species *Lactifluus austropiperatus* T.Lebel & L.Tegart and *Lf. albopicrus* T.Lebel & L.Tegart, growing in association with eucalypts, were shown to be distinct from the similar northern hemisphere species *Lf. piperatus* (L.) O.Kuntze or *Lactarius pubescens* Fr. (Crous *et al.* 2020).

In addition to dealing with these incorrectly named records, there are several introduced species of Russulaceae that are commonly reported from urban areas, plantation forestry and other modified habitats dominated by introduced plants.

From the beginning of European colonisation of Australasia in the 18th century, many exotic tree species from the northern hemisphere have been introduced for commercial forestry, flood erosion control, amenity value as street trees and in parks and gardens. Some of these trees support ectomycorrhizal associations, e.g., Betulaceae, Fagaceae, Salicaceae & Pinaceae. However, the early host introductions were not always simultaneously accompanied by ectomycorrhizal fungi. In commercial conifer forestry the initial widespread absence of associated ectomycorrhizal species hindered growth in conifer plantations (Marx 1991). In both Australia and New Zealand, subsequent accidental and deliberate introductions have led to the presence of exotic representatives from most ectomycorrhizal fungal groups in association with exotic trees. Some incidental introductions include prized edible species, such as *Boletus edulis* Bull. (Wang *et al.* 1995; Catcheside & Catcheside 2012) and *Lactarius deliciosus* (L.) Gray, whilst others are toxic and responsible for fatalities, such as *Amanita phalloides* Secr. (Rees *et al.* 2009; Roberts *et al.* 2013). Species in the Russulaceae often have a disagreeable hot or peppery taste, some are known to contain gastric irritants, for example *Russula emetica* (Schaeff.) Pers. (Lincoff & Mitchel 1977), whilst others, for example the introduced *Lactarius turpis* (Weinm.) Fr., are known to contain carcinogenic compounds


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(Sterner *et al.* 1982). In addition, several edible mycorrhizal species have been deliberately introduced into cultivation (Hall & Wang 2002; Guerin-Laguette *et al.* 2014). The introduced European trees commonly associated with ectomycorrhizal fungi are dominated by species of oak, birch, willow and pine. The typical forms of these trees are shown in Figs 1 and 2.

Here we assess the reports of some of the species commonly encountered by the public and mushroom enthusiasts and to which northern hemisphere names have been applied. This preliminary assessment is based on a selected subset of the collections available in the Fungaria of Australia and New Zealand.

## Methods

We surveyed the Russulaceae collections in selected fungaria: MEL (Royal Botanic Gardens Victoria, Melbourne, Australia), AD (State Herbarium of South Australia) and PDD (National Fungarium, Landcare Research - Manaaki Whenua, Auckland, New Zealand). While not exhaustive, these collections are representative of the range of introduced Russulaceae to be found in

**Fig. 1.** Common introduced ectomycorrhizal host trees: **A, B** Pedunculate oak (*Quercus robur*); **C, D** birch (*Betula pendula*). — A Gertrud K (flickr 37352016150), CC BY-NC-SA; A inset Degtyarev Nikolai Ivanovich (iNaturalist 62096254), CC BY-NC; B Chris (iNaturalist 108752769), CC BY-NC; C Сергей (iNaturalist 106302050), CC BY-NC; C inset Sergey Mayorov (iNaturalist 53131580), CC BY-NC; D Evgeny Boginsky (iNaturalist 73092373), CC BY-NC.

Australia and New Zealand. Representative collections identified as species originally described from the northern hemisphere were examined further. Priority examination was given to collections accompanied by photographs and descriptions of fresh material. Some older herbarium material is in poor condition, making it difficult to obtain sequence data, and even some morphological characters (pellis structure and spores) have deteriorated to the point that species determination/confirmation was not necessarily possible.

Here we provide brief descriptions for the taxa confirmed as present in Australia and New Zealand. Macromorphological details were derived from the photographs and notes associated with the collections and supplemented by information from northern hemisphere popular guides (Breitenbach & Kränzlin 2005; Kibby 2016, 2017; Laessoe & Petersen 2019) together with regional revisions (Sarnari 1998; Verbeken *et al.* 2018; Heilmann-Clausen *et al.* 1998). Microscopy was carried out on critical collections and presented where relevant.

Georeferenced collection and observation data for taxa in the Russulaceae from Australia and New Zealand were downloaded from the Global Biodiversity Information

**Fig. 2.** Common introduced ectomycorrhizal host trees: **A, B** Willow (*Salix* spp.); **C, D** Monterrey pine (*Pinus radiata*). — A Yukki Qiu (iNaturalist.org 32556414), CC BY-NC; B Rod (iNaturalist 43194202); C Paula Greer (iNaturalist 36524985); D Radinis (iNaturalist.org 32132415), CC BY-NC.

**Fig. 3.** Occurrence records for introduced Russulaceae in Australia and New Zealand.

Facility (GBIF 2021). Many northern hemisphere species recorded in these datasets most probably refer to different indigenous taxa in natural habitats and we have excluded them from our analysis (Appendix 1). Only those species supported by sequenced collections have been considered further. Occurrence maps (Fig. 3) were generated for the included species using the GBIF data download (GBIF 2021). We excluded species known from a single locality or those with no georeferenced locality data. It is important to note these maps do not represent species distributions, for which much more extensive systematic survey data would be necessary, including environmental DNA-based sampling.

Representative recent collections were selected for sequence barcoding. DNA extractions were carried out on fungarium samples using the EZNA forensic DNA kit (Omega Bio-tek, USA) or the REDExtract-N-Amp Plant PCR Kits (Sigma Aldrich, USA). The Internal Transcribed Spacer barcode region (ITS) was amplified using the standard primer pairs ITS1f/ITS4 (White *et al.* 1990; Gardes & Bruns 1993).

Twenty-six new *Lactarius* and 22 new *Russula* ITS sequences were generated for this study. Together with some data from introduced species already available in GenBank, 29 *Lactarius* and 23 *Russula* ITS sequences from Australia or New Zealand were available for analysis. Datasets for phylogenetic analyses were assembled in two steps for each genus separately. A preliminary Maximum Likelihood analysis was performed with the Australasian sequences and unpublished ITS datasets from validated European collections, including as many type specimens and as many described species as available. Identifications of Australasian specimens were then confirmed or updated and based on these results smaller subsets of publicly available ITS sequences were composed, also including non-European species where appropriate. All specimens and sequences utilised are listed in Appendix 2. The final datasets comprise 82 sequences for *Lactarius* and 101 sequences for *Russula*.

Alignments were made with the on-line version of MAFFT v. 7 (Katoh *et al.* 2019) using the iterative refinement method E-INS-I. Three *Lactarius* subgenus *Plinthogalus* and two *Lactifluus* species were utilised as outgroup for the *Lactarius* and *Russula* analysis respectively. Phylogenetic analyses were performed with Maximum Likelihood in RAxML v. 8.2.12 (Stamatakis 2014) using the CIPRES Science Gateway v. 3.3 (Miller *et al.* 2010). Trees were visualized in FigTree v. 1.4.2.

## Results

Sequence data of Australia/New Zealand collections together with comparative authoritative data are presented in Fig. 4 (*Lactarius*) and Fig. 5 (*Russula*).

We confirm the presence of 13 introduced species that are mycorrhizal with introduced angiosperm and gymnosperm hosts from a variety of modified habitats. Some species are members of groups where the taxonomy is complex or requires clarification, for example *Russula amoenolens*, *Russula nana*/*R. laccata* and *Russula ionochlora*. Issues associated with correct identification are discussed under the species entries. We have not assessed the status of all the northern hemisphere names used in Australia and New Zealand and it is probable that examination of material from a wider range of fungaria, in combination with increased collecting effort, will uncover more species.

## Species descriptions

### *Lactarius deliciosus* (L.) Gray

*Nat. Arr. Brit. Pl.* 1: 624 (1821). **IF224737.**

*Pileus* 40–120 mm diam., convex becoming centrally depressed, with an incurved margin, later becoming infundibuliform, surface viscid becoming dry, pale orange to salmon coloured, often with scrobicules, indistinctly zonate, bruising orange-red and then green. *Lamellae* subdecurrent, crowded, orange discolouring orange-red then green where bruised. *Stipe* 20–50 × 10–15 mm pale orange, surface with a whitish bloom and brighter orange scrobicules. *Latex* bright orange but slowly turns red (30 mins+). *Smell* fruity. *Taste* mild. *Spores* 7–11 × 5–8 µm ornamented with ridges forming a reticulum. **Figs 3A, 6A & B.**

***English common name.*** Saffron milkcap.

***Notes.*** *Lactarius deliciosus* is a widely consumed popular edible mushroom and was deliberately introduced into New Zealand (Guerin-Laguette *et al.* 2014). It is strictly associated with *Pinus* species. In Europe, *Lactarius quieticolor* Romagn. and *L. deliciosus* are sometimes confused in the field. *Lactarius quieticolor* differs microscopically in possessing spore ornamentation of thicker ridges. Macroscopically *L. quieticolor* shows variability in pileus and stipe colours, presence of scrobicules on the stipe and latex colour. *Lactarius deliciosus* prefers calcareous sandy soils, whereas *L. quieticolor* is often found on acidic sandy soils. *Lactarius deliciosus sensu stricto* is confirmed as the species introduced in both Australia and New Zealand. This contrasts with South America and South Africa where sequenced samples from pine plantations are closer to *L. quieticolor* (Chavez *et al.* 2015; Silva-Filho *et al.* 2020). As with many edible or common taxa there are relatively few fungarium collections, with currently no collections from Western Australia, Northern Territories or Queensland, and fewer than five from New South Wales and the Australian Capital Territory (AVH 2021). In New Zealand the species is restricted to a relatively few plantations where it has been cultivated.

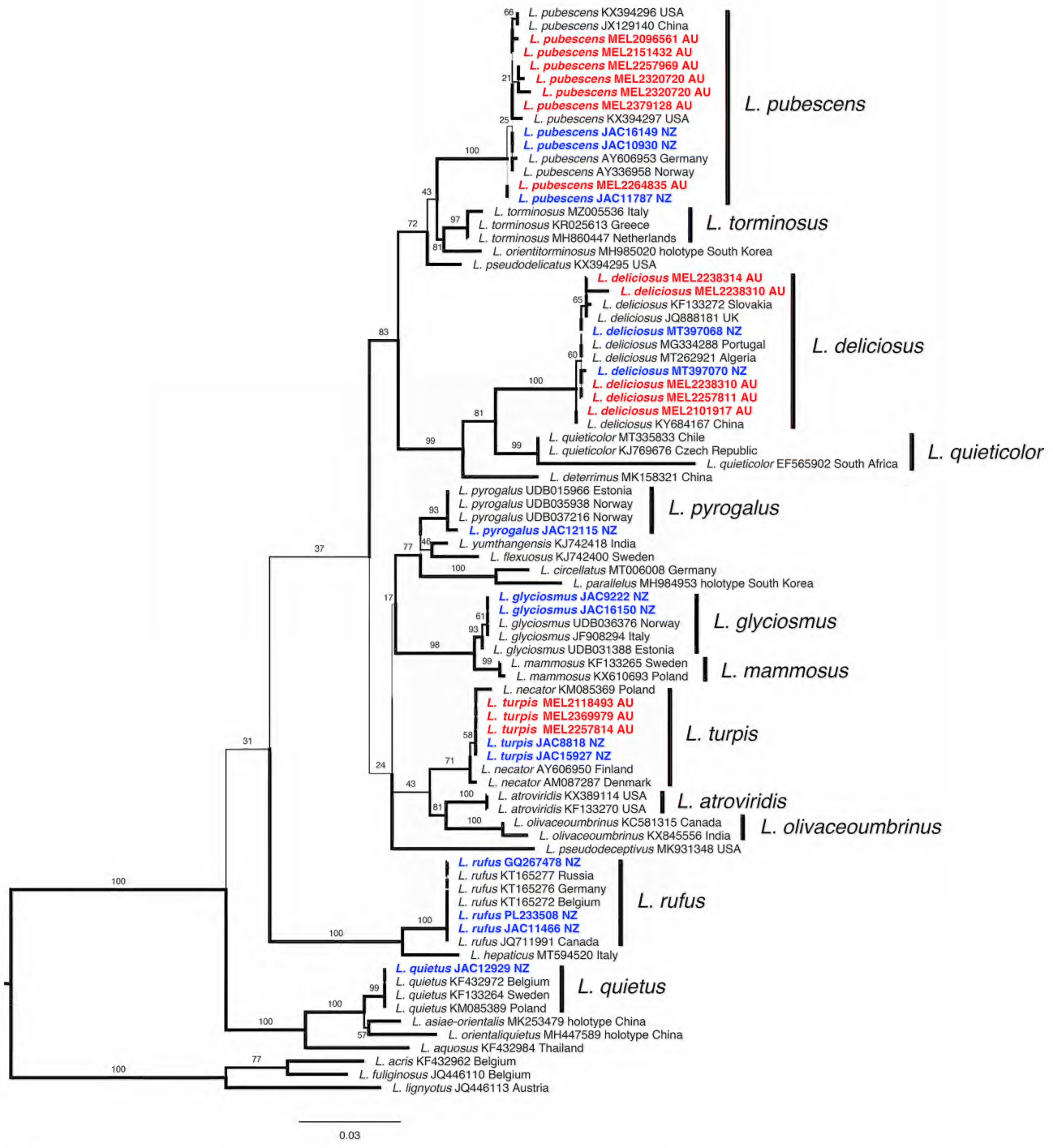


**Fig. 4.** Phylogeny showing *Lactarius*/*Lactifluus* species introduced in New Zealand (blue) and Australia (red).

### *Material examined*

**NEW ZEALAND.** SOUTH ISLAND. Canterbury, Lincoln [with *Pinus radiata* D. Don], May 2014, *A. Guerin-Laguette s.n.* (PDD105248); Tasman, Neudorf Road, Neudorf Mushrooms [with *P. radiata*], 15 May 2015, *P. Leonard s.n.* (PDD107611).

**AUSTRALIA.** SOUTH AUSTRALIA. Fleurieu Peninsula, Kuitpo State Forest, Heysen Trail, old forestry trials [with *P. radiata* and *P. canariensis* C. Sm.], 21 June 2002, *J.E. Tonkin 1021* (MEL2238314).

VICTORIA. Ballan-Daylesford road, 1.5 km from Melbourne-Ballarat Freeway, roadside verge [with *P. radiata*], 15 May 2001, *J.E. Tonkin 814* (MEL2101917); Princes Hwy, roadside verge c. 10 km north of Sale [with *P. radiata*], 27 May 2002, *J.E. Tonkin 1017* (MEL2238310).

TASMANIA. Waterworks Reservoir Reserve, Hobart, 20 Apr. 1996, *A.V. Ratkowsky 123* (MEL2257811).

### ***Lactarius glyciosmus*** (Fr.) Fr.

*Epicr. Syst. Mycol.* 348 (1838). **IF120552.**

*Pileus* 20–55 mm diam., a small central depression developing with age, greyish lilac, sometimes varying to a pale buff, thin fleshed. *Lamellae* decurrent,

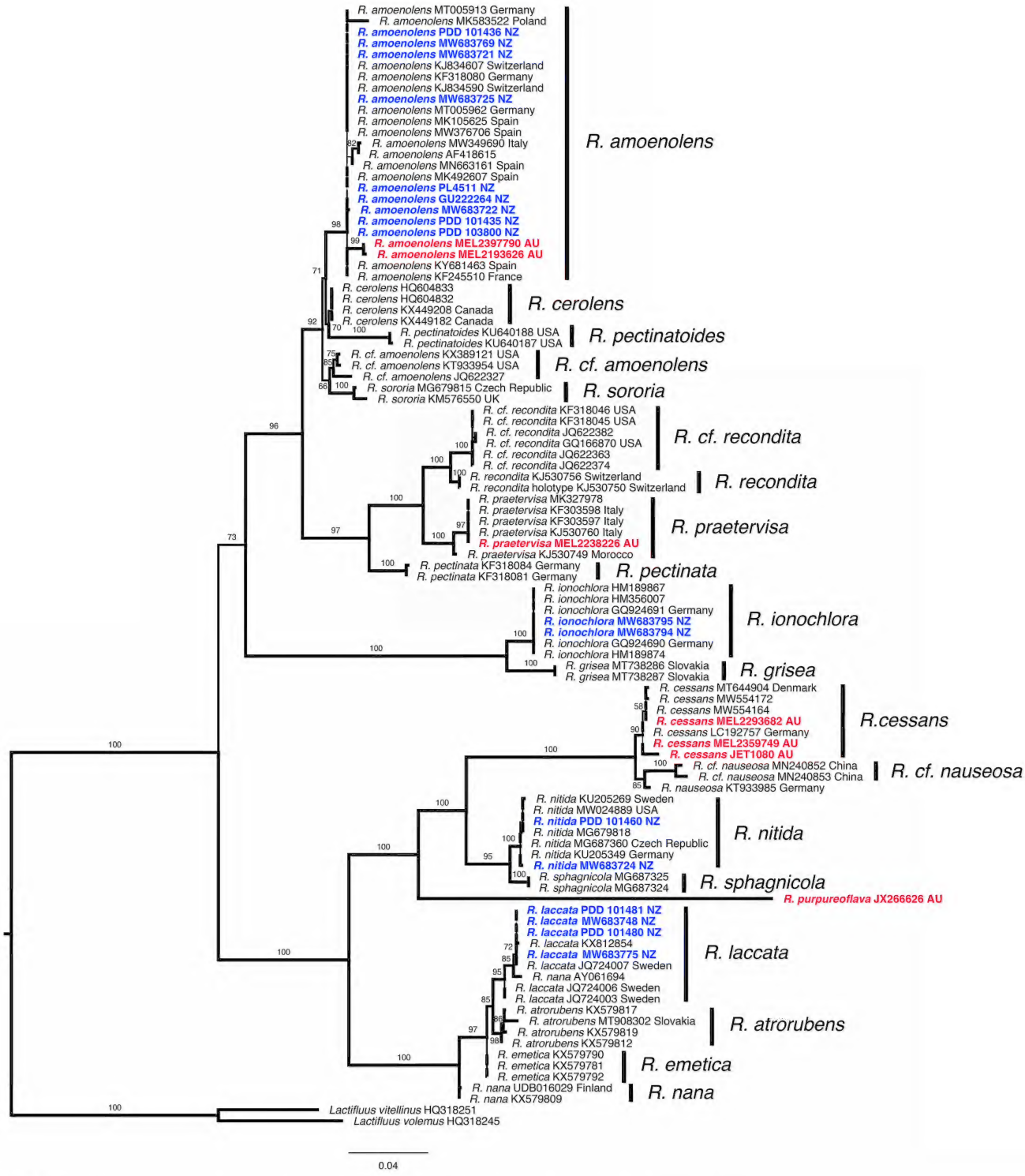


**Fig. 5.** Phylogeny showing *Russula* species introduced in New Zealand (blue) and Australia (red).

crowded, vary in colour from a pale yellowish to pale flesh, turning to a greyish lilac with age. *Stipe* 25–65 × 4–12 mm, same colour as cap, but sometimes is a little paler or with a yellowish hue. *Latex* white with an initially mild, later with a slightly acrid taste. *Smell* of coconut. *Taste* mealy to slightly bitter. *Spores* 8–9 × 5–6 µm, broadly elliptic, ornamentation verrucose, connected by thin ridges in an incomplete network. **Figs 3B & 6C.**

***English common name.*** Coconut-scented milkcap.

***Notes.*** *Lactarius glyciosmus* is reported as edible. It is one of several introduced species associated with birch (*Betula* spp.). *Lactarius mammosus* Fr. differs macroscopically from *L. glyciosmus* by the darker colours and the mostly firmer basidiocarps, and the association primarily with pines (note has also been found occasionally with birch). Microscopically, the spores are longer and more distinctly reticulate in *L. mammosus*.

Known from the South and North Islands of New Zealand but not currently known from Australia.

***Material examined***

**NEW ZEALAND.** SOUTH ISLAND. Canterbury, Christchurch, Opawa [with *Betula pendula* Roth], 22 May 2005, *H. Greenep* (PDD80929); Canterbury, Lincoln, Lincoln University [with *B. pendula*], 12 Jan. 2005, *J.A. Cooper* (PDD80997); Canterbury, Lincoln, opposite University [with *B. pendula*], 22 Apr. 2011, *J.A. Cooper* (PDD96188).

### *Lactarius turpis* (Weinm.) Fr.

*Epicr. Syst. Mycol.* 335 (1838). **IF201186**

*Pileus* 80–200 mm diam., when young with a somewhat depressed centre, with velvety zones, sometimes a shaggy rim, olive brown or yellow-green, often sticky or slimy in the middle, becoming funnel-shaped and the colour darkens to blackish in age. *Lamellae* somewhat decurrent, dirty white, stained olive-brown by old milk. *Stipe* up to 70 × 30 mm, similar colour to cap, but much lighter, sometimes with scrobiculae. *Latex* white turning brown. *Smell* indistinct. *Taste* (especially the milk) acrid. *Spores* 7 × 6 µm, ornamented with ridges. The application of alkali to the pileus produces a strong purple reaction. **Figs 3E & 6D.**

***English common name.*** Ugly milkcap.

***Notes.*** There are reports (Laessoe & Petersen 2019; Sterner *et al.* 1982) that the species contains carcinogenic compounds and should not be consumed. The species appears to be strictly associated with birch (*Betula* spp.) in Australasia, but in the northern hemisphere, while it is common under birch, it is also more broadly associated with spruce, pine and other trees in mixed woodland. It is characterised by an untidy appearance, yellow/green tinges, latex turning brown, and the purple reaction of the pileus to alkali. Recent molecular research shows that there are two similar species in Europe. One of them is conspecific with the North American species *Lactarius sordidus* Peck. Morphological and ecological characters to distinguish the two species are currently being studied (Nuytinck *et al.*, in prep.) but it seems, *L. sordidus* is more commonly associated with coniferous hosts.

Currently known from south-eastern Australia and widely distributed in New Zealand.

Ongoing debate surrounds the correct name for this taxon which has been variously referred to as *Lactarius plumbeus* (Bull.) Gray, *L. necator* (Bull.) Pers. and *L. turpis*. All three names have been used in Australasia for the single species we refer to as *L. turpis*. Noordeloos & Kuyper (1999) established that the original descriptions of *L. necator* and *L. plumbeus* are inconsistent with the modern interpretation of the taxon. They rejected *L. plumbeus* and sought to stabilise the use of *L. necator* as the preferred name by the designation of a neotype consistent with modern interpretation. However, that neotype is inadmissible (Art. 3.9; Turland *et al.* 2018) because a lectotype should be selected from the available illustrations associated with the protologue or the sanctioning treatment (Art. F.3.9; May *et al.* 2019). Currently no lectotypes for these names have been designated. *Lactarius turpis* remains the earliest unambiguous name for the taxon under consideration.

***Material examined***

**NEW ZEALAND.** NORTH ISLAND. Rangitikei, Raethi, 20 Jan. 2014 [with *Betula pendula*], *A & R Freeston* (PDD98854).

SOUTH ISLAND. Nelson, Isel Park [with *Betula* sp.], 12 Apr. 2003, *P. Leonard* (PDD77751); Canterbury, Hanmer [with *B. pendula*], 21 Feb. 2004, *J.A. Cooper* (PDD79875); Canterbury, Diamond Harbour [with *B. pendula*], 10 Apr. 2006, *J.A. Cooper* (PDD87001); Nelson, Stephens Island, 5 Mar. 2004 [with *Betula* sp.], *P. Leonard* (PDD104401).

**AUSTRALIA.** SOUTH AUSTRALIA. Mt Lofty Botanic Gardens [with *B. pendula*], 31 May 2003, *P. Catcheside 1453* (AD-C58553); Mt Lofty Botanic Gardens [with *B. pendula*], 26 Apr. 2008, *P. Catcheside 2828* (AD-C58084, AD-C59947).

VICTORIA. Rawson [with *Betula* sp.], 28 May 2013, *N.G. Karunajeewa 617* (MEL2369979).

TASMANIA. Pipeline Track [with *B. pendula*], 18 May 1996, *A.V. Ratkowsky 130* (MEL2257814).

### *Lactarius pubescens* Fr.

*Epicr. Syst. Mycol.* 335 (1838). **IF157260.**

*Pileus* 25–100 mm wide, pileus margin rolled inward and bearded with coarse white hairs when young, becoming broadly convex with a depressed centre, fibrillose except for the centre, which is sticky and smooth when fresh, white to cream, becoming reddish-orange to vinaceous on the disc with age. *Lamellae* attached to slightly decurrent, crowded, seldom forked, whitish to pale yellow with pinkish tinges, slowly staining brownish ochraceous when bruised. *Stipe* 20–65 × 6–13 mm, silky, whitish when young, becoming ochraceous from the base up when older, apex usually tinged pinkish, often with a white basal mycelium. *Latex* white, unchanging, not staining tissues, taste acrid. *Smell* faintly like geraniums or sometimes pungent. *Taste* acrid. *Spores* 6–8.5 × 5–6.5 µm, elliptic, ornamented with amyloid warts and ridges that sometimes form a partial reticulum, prominences up to 1.5 µm high. **Figs 3C, 6E & F.**

***English common name.*** Downy milkcap.

***Notes.*** Always associated with birch (*Betula* spp.). *Lactarius pubescens* is considered toxic by some authors (Hall *et al.* 2003), although the acrid taste reduces the likelihood of consumption. It can be confused with

*L. torminosus* (Schaeff.) Pers., which is also a tomentose and acrid species growing with birch. The colours in *L. pubescens* are much paler, almost whitish, while *L. torminosus* always has the dominant pinkish brick tone. The spores of *L. torminosus* are distinctly larger than those of *L. pubescens*. *Lactarius torminosus* is not currently confirmed to be present in Australia or New Zealand and records under this name are likely misidentifications.

Currently known from southern Australia and widely distributed in New Zealand.

*Lactarius pubescens* is part of a species complex consisting of several closely related species, some of which are hard to delimit based on ITS sequences alone (Nuytinck *et al.* 2014). More study is needed to disentangle this complex. In our phylogenetic analyses three species that are well separated are included: *L. pubescens*, *L. orientitorminosus* H. Lee, Wisitr. & Y.W. Lim and *L. torminosus*. Other species like *L. scoticus* Berk. & Broome and *L. tesquorum* Malençon are excluded from the analysis, because their species delimitation is unclear.

### *Material examined*

**NEW ZEALAND.** NORTH ISLAND. Gisborne, Eastwoodhill Arboretum [with *Betula pendula*], 16 May 2013, *J.A. Cooper* (PDD97028)

SOUTH ISLAND. Canterbury, Christchurch Riverview Terrace [with *B. pendula*], 1 Jan. 2005, *H. Greenep* (PDD86879); Canterbury, Christchurch, Little Hagley Park [with *B. pendula*], 26 Mar. 2009, *J.A. Cooper* (PDD95387); Canterbury, Lincoln, opposite University [with *Betula* sp.], 22 Apr. 2012, *J.A. Cooper* (PDD96184); Nelson, Rabbit Island [with *B. pendula*], 28 Apr. 2012, *P. Leonard* (PDD102724).

**AUSTRALIA.** SOUTH AUSTRALIA. Adelaide, St Peters [with *B. pendula*, 20 May 1980, *I. McDonald I-25* (AD-C31546); Mt Lofty Botanic Gardens [with *B. pendula*], 7 June 2000, *P. Catcheside 449* (AD-C58319); South Australia, Mt Lofty Botanic Gardens upper carpark [with *B. pendula*], 13 May 2001, *P. Catcheside 769* (AD-C58547).

AUSTRALIAN CAPITAL TERRITORY. Canberra, Macquarie, 8 km NW of Capital Hill [with *Betula* sp.], 28 Mar. 1995, *H. Lepp 1155* (MEL2096561).

VICTORIA. Eastern Highlands, Malinns', 53 km N of Orbost on the Bonang Road [with *B. pendula*], 26 May 2002, *K.R. Thiele 2778* (MEL2151432).

TASMANIA. Richmond [with *B. pendula*], 24 Apr. 2003, *J. Piscioneri 388* (MEL2257969).

## *Lactarius pyrogalus* (Bull.) Fr.

*Epicr. Syst. Mycol.* 339 (1838). **IF157078.**

*Pileus* 50–100 mm diam., convex to flat, later becoming funnel shaped, sometimes faintly concentrically banded, thin fleshed, becoming sticky when moist, grey fawn, sometimes with a yellowish tinge, and pink and purple tinges not unknown. *Lamellae* slightly decurrent, yellow to flesh coloured, though later become a cinnamon-ochre colour, well-spaced. *Stipe* 40–60 × 7–15 mm, cylindrical but sometimes slightly swollen at the base, whitish or concolorous with the cap; flesh whitish. *Latex* abundant white, drying grey with greenish tinge. *Smell* slightly fruity. *Taste* very hot, acrid. *Spore print* light ochre. *Spores* 7–8 × 5.5–7 µm, broadly elliptic, ornamentation of warts joined by moderately thick ridges in a well-developed network, 1 µm high. **Fig. 6G.**

***English common name.*** Fire-milk lactarius.

***Notes.*** *Lactarius pyrogalus* is not considered edible due to the intensely hot and unpleasant taste. In Australasia it is currently only found in association with hazel (*Corylus avellana* L.). In Europe, *Lactarius circellatus* Fr. has similar colours and microscopical features to *L. pyrogalus*, however *L. circellatus* is strictly associated with hornbeam (*Carpinus* L.). Furthermore, *L. pyrogalus* differs by the more distant lamellae, which are often darker and more yellowish.

*Lactarius pyrogalus* is currently known only from a single site in New Zealand.

### *Material examined*

**NEW ZEALAND.** NORTH ISLAND. Wairarapa, Masterton, Upper Manaia Road [with *Corylus avellana*], 5 June 2011, *D. Batchelor* (PDD96354); Wairarapa, Masterton, Upper Manaia Road [with *C. avellana*], 1 May 2012, *D. Batchelor* (PDD102506).

## *Lactarius quietus* (Fr.) Fr.

*Epicr. Syst. Mycol.* 343 (1838). **IF157234.**

*Pileus* 50–80 mm diam., convex becoming flattened with small depression in the centre, dull matt reddish brown with a tint of cinnamon, sometimes with darker concentric bands or spots, dry, not sticky when moist. *Lamellae* slightly decurrent, brownish-white becoming pale reddish brown with mauve hints in age. *Stipe* 40–90 × 10–15 mm, same colour as cap, or a little darker. *Latex* white or cream in colour, initially thick becoming whey-like in age. *Smell* strong oily, likened to 'bedbugs' or 'wet laundry'. *Taste* mild at first, becoming acrid. *Spores* 7.5–9 × 6.5–7.5 µm, oval with plentiful warts joined by numerous ridges, forming a well-developed network. **Fig. 6H.**

***English common name.*** Oak milkcap, oakbug milkcap.

***Notes.*** *Lactarius quietus* is recognised from the characteristic association with oaks (*Quercus* spp.), the reddish brown colours, the often somewhat zonate aspect and the distinct smell of Pentatomidae bugs, the so-called stink bugs or bedbugs. This smell is described by some people as rancid oil or wet laundry. The species can be confused with two rare European species: *Lactarius zugazae* G. Moreno, Montoya, Bandala & Heykoop (only known from a few records in Southern Europe), which has a more greasy and reddish-vinaceous

**Fig. 6.** **A** *Lactarius deliciosus*; **B** scrobiculae of *L. deliciosus*; **C** *L. glyciosmus* (PDD113295); **D** *L. turpis* (PDD113074); **E** *L. pubescens* (PDD113294); **F** bearded margin of *L. pubescens*; **G** *L. pyrogalus*; **H** *L. quietus* (PDD 97029). — G epopov (iNaturalist 25893615), CC BY.

**Fig. 7. A** *Lactarius rufus* (PDD105425); **B** *Russula amoenolens*; **C** *R. amoenolens*, white form (PDD106199); **D** *R. cessans* (MEL2238226); **E** *R. ionochlora* (PDD80994); **F** *R. laccata*; **G** *R. nitida* (PDD 86996); **H** *R. praetervisa* (MEL 2359749). — B davidwhyte (iNaturalist 36154374), CC BY-SA; F alice_shanks (iNaturalist 9635839), CC BY-NC.

pileus and a taste of raw cauliflower. Another similar and related species is *L. fraxineus* Romagn., which is smaller, with a more sticky pileus and stem, and without the characteristic smell. Neither of these rare species is reported from Australasia. *Lactarius quietus* var. *incanus* Hesler & A.H.Sm., described from North America with oaks, has a fragrant smell like burnt sugar and is phylogenetically distinct. Early reports of *L. quietus* from Australia compiled by May & Wood (1997) can be discounted as misidentifications, as no evidence of association with exotic trees was provided in the original reports.

*Lactarius quietus* is currently known only from a single site in New Zealand.

### *Material examined*

**NEW ZEALAND.** NORTH ISLAND. Gisborne, Eastwoodhill Arboretum [with *Quercus* sp.], 16 May 2013, *P. Leonard* (PDD97029).

## *Lactarius rufus* (Scop.) Fr.

*Epicr. Syst. Mycol.* 347 (1838). **IF229473.**

*Pileus* up to 80 mm diam., initially convex, often with a small central umbo, becoming flat, eventually acquiring a shallow central depression, dark brick, bay, or red-brown, dry and matt. *Lamellae* slightly decurrent, cream, becoming coloured as the pileus in age, only paler. *Stipe* 30–50 × 5–15 mm, cylindrical, the same colour or paler than cap. *Latex* watery white, initially mild, gradually becoming very hot, and acrid after a minute or so. *Smell* none. *Taste* the same as the latex. *Spores* broadly ellipsoidal, 6.5–9 × 5.5–6.5 µm, ornamented with a well-developed and almost complete network of ridges. **Figs 3D & 7A.**

***English common name.*** Rufous milkcap.

***Notes.*** *Lactarius rufus* is widely reported across the northern hemisphere in association with birch, spruce, firs and pines. In New Zealand *Lactarius rufus* is reported only with pines, and especially with *Pinus radiata* in plantations (Walbert *et al.* 2010). Though variable in colour, the species is recognized by the red/brown pileus surface (especially when young) and the burning acrid taste. It can be confused with the European *Lactarius hepaticus* Plowr., which is currently not confirmed from Australasia. *Lactarius hepaticus* has a smoother and usually duller brown pileus, and a mild to bitter taste. The literature reports of *L. rufus* from Australia by Eygelsheim (1981) can be discounted as there is no evidence of association with exotic trees.

Currently known only from New Zealand.

### *Material examined*

**NEW ZEALAND.** SOUTH ISLAND. Canterbury, Christchurch, Bottle Lake [with *Pinus radiata*], 26 Dec. 2009, *J.A. Cooper* (PDD95619); Christchurch, Bottle Lake [with *P. radiata*], 31 May 2010, *J.A. Cooper* (PDD95865); Christchurch, Bottle Lake [with *P. radiata*], 26 Mar. 2011, *J.A. Cooper* (PDD96173); Christchurch, Spencer Park [with *P. radiata*], 2 Jan. 2014, *J.A. Cooper* (PDD105425).

## *Russula amoenolens* Romagn.

*Bull. Mens. Soc. Linn. Lyon* 21: 111 (1952). **IF305349.**

*Pileus* 20–70 mm, hemispherical and deeply inrolled when young, later plane to infundibuliform, strongly grooved, moist, pale tan to dark brown, and with a pure white version also known. *Lamellae* white, often forked. *Stipe* 25–55 × 10–20 mm, cylindrical to ventricose. *Smell* sour or rancid and often described as like ripe camembert cheese, although different people interpret the smell variably. *Taste* extremely acrid. *Spores* 6.5–8 × 4.5–6 µm ornamented with isolated conical warts. **Figs 3F, 7B & C.**

***English common name.*** Camembert brittlegill.

***Notes.*** *Russula amoenolens* is a very common introduced species to which various names have been applied in Australia and New Zealand, including *R. amoenolens*, *R. sororia* (Fr.) Romell, *R. pectinata* Fr. and *R. pectinatoides* Peck. Sequence data suggest all Australasian collections under these names refer to a single species we are calling *R. amoenolens* and it is identical to collections from various parts of Europe.

The species has a broad ectomycorrhizal host affiliation that in New Zealand includes pines (*Pinus* spp.), cedar (*Cedrus deodara* (Roxb.) G.Don), lime (*Tilia cordata* Mill.), oak (*Quercus robur* L.), and beech (*Fagus sylvatica* L.). While in Australia, this species has currently only been found affiliated with oak species. In Spain, Santolamazza-Carbone *et al.* (2019) found *R. amoenolens* on ECM root tips of *Eucalyptus nitens* (H.Deane & Maiden) Maiden and *E. globulus* Labill. suggesting the potential for the species to associate with native *Eucalyptus* in Australia. The spread of introduced ectomycorrhizal species within native ecosystems is documented in the case of *Amanita muscaria* and *Nothofagus* Blume, and *R. amoenolens* may, in future, show a similar pattern.

Stevenson (1981) referred to collections of a species with limes in a New Zealand park as *R. pectinata*/*pectinatoides*. Recent re-collections from under the same trees in Wellington confirm *R. amoenolens* and not *R. pectinata* or *R. pectinatoides*. Current phylogenetic data indicate there are other distinct taxa in the group identified as *R. amoenolens*. Further work is necessary to establish the correct application of names in this species complex. The similar but phylogenetically distinct *Russula praetervisa*, recorded from Australia, typically has red staining at the stem base and a less fetid odour. Records of *R. pectinata* and *R. pectinatoides* from Australia compiled by May & Wood (1997) are generally of a fungus growing in native forests and are likely to be misidentifications for a native species, such as *Russula neerimea* Grgur.

### *Material examined*

**NEW ZEALAND.** NORTH ISLAND. Auckland, Sandringham, Potter's Park [with *Pinus radiata*], 16 July 1967, *R.F.F.R. McNabb* (PDD26579); Auckland, Sandringham, Potter's Park [with *P. radiata*], 18 June 1967, *R.F.F.R. McNabb* (PDD26580); Auckland, Auckland Domain [with *Quercus* sp.], 16 Apr. 1972, *G.M. Taylor* (PDD84320); Auckland, Old Govt. House, 22 Apr. 1982, *G.M. Taylor* (PDD85681); Wellington, Botanic Gardens, 25 July 1960, *G. Kelly & J. Mason* (PDD86112); Auckland, Western Park [with *Quercus* sp.], 30 Apr. 2006, *P.R. Johnston* (PDD88354); Wellington, Central Park [with *Tilia* sp.], *G. Stevenson* (PDD90385); Wellington, Central Park [with *Pinus* sp.], 30 Apr. 1978, *G. Stevenson* (PDD90386); Wellington, Central Park [with *T. cordata*], 25 Feb. 2012, *J.A. Cooper* (PDD96535); Wairarapa, Greytown, Kuratawhiti Street [with *T. cordata*], 10 May 2007, *S. Cook* (PDD104432).

SOUTH ISLAND. Canterbury, Christchurch, Hagley Park, 24 Mar. 1968, *R.F.F.R. McNabb* (PDD31687); Canterbury, Christchurch, Little Hagley Park [with *Pinus maritima*], 29 May 2004, *J.A. Cooper* (PDD80615); Canterbury, Christchurch, Little Hagley Park [with *Quercus robur*], 25 Mar. 2005, *J.A. Cooper* (PDD80693); Canterbury, Christchurch, Cholmondley Park [with *Tilia cordata*], 12 Mar. 2005, *J.A. Cooper* (PDD80743); Canterbury, Lincoln, CASC [with *Q. robur*], 5 Jan. 2005, *J.A. Cooper* (PDD80990); Canterbury, Christchurch, South Hagley Park [with *P. radiata*], 9 Jan. 2005, *J.A. Cooper* (PDD80993); Otago, Kuriheka [with *Quercus* sp.], 10 Jan. 1970, *L.R. Taylor* (PDD84226); Canterbury, Christchurch, Hagley Park [with *Pinus* sp.], 13 Apr. 2009, *J.A. Cooper* (PDD95417); Canterbury, Lincoln, CASC grounds [with *Leptospermum scoparium* J.R.Forst. & G.Forst.], 22 Apr. 2013, *J.A. Cooper* (PDD96849); Nelson, Golden Downs [with *Populus* sp.], 21 Mar. 2004, *P. Leonard* (PDD101436); Canterbury, Christchurch, Little Hagley Park [with *Q. robur*], 21 Mar. 2014, *J.A. Cooper* (PDD105522); Canterbury, Christchurch, Ernle Clark Reserve [with *Q. robur*], 30 Jan. 2016, *J.A. Cooper* (PDD106199).

**AUSTRALIA.** VICTORIA. Melbourne, Camberwell, Range St [with *Quercus palustris* Munchh.], 19 May 2003, *J.H. Ross 4130* (MEL2193626); Victoria, Melbourne, South Yarra, the Domain [with *Quercus* sp.], 11 May 2016, *T. Lebel 2745* (MEL2397790).

## *Russula cessans* A.Pearson

*Naturalist* 101 (1950). **IF305359.**

*Pileus* 30–100 mm diam., convex becoming broadly convex to flat, viscid when wet, blood red to purplish red to brownish purple, often with a darker centre; on drying out pink/red around the margin. *Lamellae* adnexed, close, pale yellow maturing to a deep orange-ochre. *Stipe* 25–50 × 8–20 mm, typically slightly swollen towards base, white, not bruising. *Smell* not distinct. *Taste* mild. *Spore print* yellow. *Spores* 8–9 × 7–8 µm, subglobose to broadly ellipsoid; ornamented with warts to 1 µm connected with short lines in a partial net. **Fig. 7D.**

***English common name.*** Tardy brittlegill.

***Notes.*** *Russula cessans* is known from only a few collections in Australia. The reddish to purple cap, yellowish-orange lamellae and white stipe with mild taste and odour, and association with pines is distinctive. It resembles a native Australian species, *Russula purpureoflava* Cleland, that is associated with *Eucalyptus*. However, our molecular analyses place that species quite distant from *R. cessans*. Some collections originally identified as *Russula integra* (L.) Fr. were found to be *R. cessans*. The name *R. integra* has been applied broadly to any purplish toned *Russula* found with exotic trees. More collections identified as *R. integra* require examination to exclude its presence. The species is typically brown tinged with violet, purple, yellow or green, and the spore print is bright yellow.

### *Material examined*

**AUSTRALIA.** VICTORIA. Melbourne, Banyule, Yallambie Park [with firs], 15 May 2012, *P.M. Grey 2012/1* (MEL2359749); Victoria, Balnarring, Buckley Nature Reserve, Myers Road boundary [with *Pinus radiata*], 12 June 2004, *J.E. Tonkin 1139* (MEL2293682); Victoria, Daylesford-Ballan Road, c. 1 km north of Ballarat Fwy turnoff, on eastern verge [with *Pinus radiata*], 20 Apr. 2003, *J.E. Tonkin 1080* (MEL2238372).

## *Russula ionochlora* Romagn.

*Bull. Mens. Soc. Linn. Lyon* 21: 110. **IF305380.**

*Pileus* 50–100 mm, hemispherical becoming centrally depressed to slightly infundibuliform, dry, margin ± grooved, colour very variable, but always with yellowish-green or magenta pastel shades accompanied by grey, pink or light brown. *Lamellae* white becoming cream coloured, with lamellulae, sometimes rust-spotted. *Stipe* 40–80 × 10–20 mm, cylindrical. *Smell* none to faintly fruity. *Taste* mild to slightly acidulous. *Spores* 6.5–8.5 × 5–6.5 µm with a low ornamentation of partially connected warts. **Figs 3G & 7E.**

***English common name.*** Oil-slick brittlegill.

***Notes.*** This species has a rather broad host affiliation in New Zealand that includes oaks, limes and cedar. The colour variation has led to the interchangeable use of the names *Russula grisea* Fr. and *R. ionochlora*. The two species are documented to be closely related and morphologically separated by rather subtle differences in the pileus cuticle structure. However, different concepts of *R. grisea* are found in the literature and current phylogenetic data indicates some complexity. In this instance our sequences fall in a clade that probably corresponds to *R. ionochlora*. It is the sister clade of *R. grisea*. A type study is needed to settle this question.

Only known from New Zealand.

### *Material examined*

**NEW ZEALAND.** SOUTH ISLAND. Canterbury, Lincoln, CASC grounds on roadside [with *Cedrus libani* A.Rich.], 27

Apr. 2011, *J.A. Cooper* (PDD96205); Canterbury, Lincoln, Liffey [with *Quercus robur*], 5 May 2011, *J.A. Cooper* (PDD96220); Canterbury, Christchurch, Thorrington St [with *Tilia cordata*], 30 Jan. 2016, *J.A. Cooper* (PDD106200).

### ***Russula laccata*** Huisman

*Fungus (Wageningen)* 25: 40 (1955). **IF305382.**

*Pileus* 15–50 mm, hemispherical becoming flat, with slightly depressed centre, always sticky, at first dark purple/olive brown later becoming paler to olive brown with purple, magenta and sometimes with blue/greens particularly at edge, edge often lightly grooved. *Lamellae* white, without lamellulae. *Stipe* to 50 × 10 mm, white, sometimes bruising pink at the extreme base. *Smell* fruity. *Taste* very hot. *Spores* 7.5–8.5 × 5.5–7.5 µm with prominent warts forming an almost complete reticulum. **Figs 3H & 7F.**

***Notes.*** *Russula laccata* and *R. nana* Killerm. are small red species that are closely related (Noffsinger & Cripps 2021). In Europe, *R. laccata* is described as laccate-capped species, often with purple-red to carmine colours and associated with willows in swampy areas. *Russula nana* is reported as having scarlet-red to pink-red caps and being non-laccate, associated with dwarf willows and *Dryas* L., but also reported with *Helianthemum* Mill. in the UK (Kibby 2012). However, the circumscription and distribution of these two similar species requires further investigation. New Zealand collections are usually laccate, with red/purple/blue colours and found along riverbanks and swampy areas where willow (e.g. *Salix fragilis* L., *S. caprea* L., *S. cinerea* L., *S. matsudana* L., *S. babylonica* L.) have invaded or been established for flood control.

Only known from New Zealand.

#### *Material examined*

**NEW ZEALAND.** SOUTH ISLAND. Canterbury, Christchurch, Travis Wetland Park [with *Salix caprea*], 8 Feb. 2009, *J.A. Cooper* (PDD95269; Canterbury, Christchurch, Travis Wetland Park [with *Salix* sp.], 29 Dec. 2009, *J.A. Cooper* (PDD95623); Canterbury, Ohoka [with *S. fragilis*], 4 Jan. 2009, *J.A. Cooper* (PDD 95647); Canterbury, Lindis Pass Road, Lindis River [with *S. fragilis*], 12 May 2010, *J.A. Cooper* (PDD96519); Canterbury, Oxford [with *Salix* sp.], 7 May 2010, *P. Leonard* (PDD101480).

### ***Russula nitida*** (Pers.) Fr.

*Epicr. Syst. Mycol.* 361 (1838). **IF211457.**

*Pileus* 20–60 mm diam., convex becoming flat or depressed, margin strongly furrowed, purple to pink, thin-fleshed. *Lamellae* adnexed, widely spaced and shallowly intervenose, cream. *Stipe* 20–90 × 5–20 mm white or pinkish. *Smell* not distinct. *Taste* mild to slightly acidic. *Spores* 8–11 × 6–9 µm, hyaline; ornamented with spines and without connectives. **Figs 3I & 7G.**

***English common name.*** Purple swamp brittlegill.

***Notes.*** A relatively easy species to identify, fruiting consistently with birch, especially where they occur along riverbanks. The phylogeny presented does not include a sequence of the type and is based on the morphological and ecological concept of this species in Europe.

Currently known only from South Island, New Zealand.

#### *Material examined*

**NEW ZEALAND.** SOUTH ISLAND. Otago, Dunedin, Waiora Scout Camp, Whare Flat [with *Betula* sp.], 11 May 2008, *P. White* (PDD101460); Canterbury, Christchurch, Opawa [with *B. pendula*], 22 May 2005, *H. Greenep* (PDD80930); Canterbury, Lincoln, Lincoln University [with *B. pendula*], 12 Jan. 2005, *J.A. Cooper* (PDD80998); Canterbury, Christchurch, Fifield Terrace [with *B. pendula*], 5 Apr. 2006, *J.A. Cooper* (PDD86996); Canterbury, Christchurch, Riverlaw Terrace [with *B. pendula*], 13 Mar. 2008, *J.A. Cooper* (PDD95369).

### ***Russula praetervisa*** Sarnari

*Monogr. Ill. Gen. Russula Europa* 1: 463 (1998). **IF446396.**

*Pileus* 25–80 mm diam., convex becoming broadly convex to flat with slightly depressed centre, with bumpy striate margin, viscid when wet, various shades of dull yellowish brown, sometimes with an olive tinge, often with a darker centre. *Lamellae* adnexed, close, pale cream or yellowish, becoming light ochre in age, some forking. *Stipe* 28–50 × 5–15 mm, white, often with reddish-brown or purplish rusty spots near base. *Smell* old or burnt rubber, oily, sometimes fishy. *Taste* oily, mild or only very slightly bitter. *Spore print* dark cream. *Spores* 7–8.5 × 5.5–7 µm, ellipsoidal; ornamented with warts to 0.7 µm connected by ridges in partial mesh. **Fig. 7H.**

***Notes.*** *Russula praetervisa* is part of a group of similar species including *R. amoenolens*, *R. sororia*, *R. pectinata* and *R. pectinatoides*. It is mostly found under evergreen oaks (*Quercus ilex* L. & *Q. suber* L.), but has been recorded under pines (*Pinus pinaster* Aiton, *P. pinea* L. and *P. halepensis* Mill.; Melera *et al.* 2017). Careful microscopic observation and chemical testing is necessary to separate this species (slightly bitter tasting, spores with warts connected in a partial mesh) from several other similar species. *Russula recondita* Melera & Ostellari, not yet recorded from New Zealand or Australia, has a paler cap, mild taste and fruitier smell, and spores with isolated warts barely connected by short lines, and very broad host association. The common *R. amoenolens* does not have red staining at the stipe base and has a stronger fetid odour. The species has not yet been found in New Zealand.

#### *Material examined*

**AUSTRALIA.** VICTORIA. Melbourne, Royal Botanic Gardens Victoria, garden bed at entrance to Gardens

House [with *Quercus* sp.], 16 Apr. 2002, *J.E. Tonkin 927* (MEL2238226).

## Discussion

This survey includes verified records of fungal species in the Russulaceae family that have been introduced into Australia and New Zealand. These species are usually associated with introduced plants in modified habitats. Documenting the occurrence and distribution of these introduced fungal species is important for several reasons: (1) the majority of introduced fungi are concentrated in urban areas where they are more likely to be gathered for consumption; (2) the general ability of the public to correctly identify fungal species is low, due to lack of accessible information allowing unambiguous identification, and the inherent difficulty in identifying fungi; (3) a greater understanding of the occurrence and distribution of verified records provides useful insights into the ecology of these fungi.

Species occurrence data available for Australia and New Zealand and made available through aggregation portals, such as the Atlas of Living Australia (ALA) and the Global Biodiversity Information Facility (GBIF), contain records of taxa we have not included in this report (Appendix 1). Reports of these taxa require confirmation as present in Australia or New Zealand through the deposit of verified and sequenced collections in recognised fungaria. There are several sources of potential error in these data. *Russula* and *Lactarius* contain many species that are difficult to identify from macromorphology, and in some groups species concepts and correct names remain uncertain. Also, historically the names of similar northern hemisphere species have been applied to several indigenous taxa in Australia and New Zealand. There are no verified reports of ectomycorrhizal species with a natural north/south hemisphere distribution. Modern phylogenetic data confirm that different biogeographic regions usually support indigenous macro-fungal species, often with restricted distributions and sometimes with very similar morphology (cryptic species) (Li *et al.* 2010; Bazzicalupo *et al.* 2018). The indigenous species in natural habitats are often undescribed or difficult to identify and so it is unsurprising to find many misidentifications in the available records. There remains the possibility of the unrecognised spread of introduced exotic species and there are some reports of novel associations of introduced fungi with native trees and subsequent spread into native habitats (e.g. Dunk *et al.* 2012).

Another source of potential systematic misidentification results from eDNA data from the Biome of Australia Soil Environments (BASE) (Bissett *et al.* 2016). The data are associated with two issues: (1) the relatively short ITS1 sequence region used for the survey does not adequately resolve many species; (2) accurate matching is dependent on representative species barcodes being present in the dataset used for matching, and the coverage of southern hemisphere fungal taxa in these databases remains relatively poor. This dataset reported species that, as currently identified, are unlikely to be present in Australia and it was excluded from our analysis.

Records of introduced host-fungal associations provide useful insights into the ecology of these systems. Species of introduced ectomycorrhizal fungi have been implicated in the spread of wilding pines in New Zealand, and as food for introduced pest animal species as part of that process (Wood *et al.* 2015). Many ectomycorrhizal species are host-restricted, at least at family level. However, in their introduced range, changes in the patterns of host associations relative to their native range have been detected, and this has implications for understanding the invasive spread of both the fungi and their host plants (Dickie *et al.* 2017). Some studies have shown that the formation of new associations between introduced fungi and native host species is low (Dickie *et al.* 2010), whilst there are well documented exceptions, for example *Amanita muscaria* has spread into *Nothofagus* forests in both Australia and New Zealand (Dunk *et al.* 2012; Orlovich & Cairney 2004). In New Zealand, the species has currently spread throughout most native southern beech forests. The impact of invasive *Amanita muscaria* on native mycorrhizal fungi is unknown. Observation and collection data indicate other introduced ectomycorrhizal species have the potential to become similarly invasive, such as species of *Paxillus* (Batsch) Fr., *Hebeloma* (Fr.) P.Kumm., *Laccaria* Ber. & Broome and boletes. For example, in New Zealand's South Island, the braided river systems are often flanked by willows, originally planted for river management purposes, but now spreading inland into native forests providing a potential pathway for spread of associated mycorrhizal fungi. In urban areas, there are verified records of introduced species associated with planted native species, for example PDD95499 (SCD 2021) is a record of the introduced *Hebeloma mesophaeum* (Pers.) Quél. and PDD106951 is a record of the introduced *Xerocomellus cisalpinus* (Simonini, H.Ladurner & Peintner) Klofac, both in mycorrhizal association with planted native *Fuscospora solandri* (Hook.f.) Oerst. Conversely, indigenous ectomycorrhizal fungal species, which normally associate with indigenous hosts, have the potential to associate with introduced trees, which may then provide pathways for range expansion. For example, in New Zealand, there are recent records of *Amanita marmorata* (Cleland & E.-J.Gilbert) E.-J. Gilbert, in the death-cap group, forming associations with *Pinus radiata* in plantation forests (PDD99082). The species is naturally associated with myrtaceous hosts in Australia and New Zealand. Tracing the historical pathways by which exotic ECM fungi have been introduced can provide important insights into how ectomycorrhizal fungal species are initially translocated, and subsequently become established and spread.

All the currently known introduced species of *Russula* and *Lactarius* appear to be European in origin and are associated with introduced European and North American trees in several families (Pinaceae, Fagaceae, Malvaceae, Betulaceae, Salicaceae). Historical records indicate that "larch, spruce and scotch firs" were first introduced into Australia prior to 1840, presumably from England (Kloot 1985). It is interesting to note the absence of North American ectomycorrhizal *Russula* and *Lactarius* species in *Pinus radiata* plantations. The North American *P. radiata* (Monterey pine) was first introduced into Australia and New Zealand in the 1850s (Fielding 1957; Berg 2008). The plants were shipped in wardian cases and said to originate in Exeter, England (Wilson 1983). The plants were the progeny of material sent to England from the USA in 1833 by David Douglas. These original plants from England were probably carrying ectomycorrhizal fungi on their roots, but not of North American origin. There have been subsequent introductions of a relatively smaller number of ectomycorrhizal fungi from North America, for example, *Suillus pungens* Thiers & A.H. Sm., *S. quiescens* T.D. Bruns & Vellinga and *S. salmonicolor* (Frost) Halling, which are associated with *Pinus radiata* in New Zealand (SCD 2021).

The diversity of introduced ectomycorrhizal species discussed in this paper is incomplete for Australia. The limited current knowledge of introduced species will change as more collections are made in broader geographic regions of Australia. There is an important role for citizen science platforms like *iNaturalist* in documenting the indigenous and introduced fungi and highlighting the potential occurrence of newly introduced species for subsequent confirmation through the deposit and analysis of vouchers in recognised fungaria. While quarantine regulations are now in place to prevent the introductions of potentially new problematic species; many of the taxa discussed here are historical legacies predating current regulations.

In New Zealand, the *Hazardous Substances and New Organism (HSNO) Act 1996*, section 44 (General Duty to Inform), states that "Every person is under a duty to inform the Ministry, as soon as practicable in the circumstances, of the presence of what appears to be an organism not normally seen or otherwise detected in New Zealand." The act is intended to facilitate the detection of organisms that are "capable, or potentially capable, of causing unwanted harm to any natural and physical resources or human health". The *HSNO Act* supports the protection of New Zealand's economy and natural environment. The implementation of the act implies the existence of a complete and maintained inventory of all organisms present in New Zealand. The New Zealand Organisms Register (NZOR) is an information infrastructure intended to deliver the inventory of recorded organisms. However, this inventory of recorded organisms will be a fraction of the total, which will include undescribed species and undetected introduced species. Increasingly, the detection and validation of species present in an area is being facilitated by the collection and interpretation of eDNA data. The accuracy of these surveys depends critically on the existence of verified sequence barcodes. In New Zealand there is an ongoing effort to generate sequence barcodes for the described fungal species to support the implementation of the *HSNO Act* and also the interpretation of eDNA data. The work necessarily includes all fungal species, and not just those that are potentially pathogenic or invasive. For the agaricoid fungi an additional focus has been the verification of the presence of introduced species. That program of work has provided a substantial baseline of data. For these reasons, New Zealand is relatively well-documented for the species included in this report.

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**Appendix 1.** Species with New Zealand/Australia observation/collection records available through GBIF but without sequence verified collections.

| Taxon | Data Source | Comment |
|---|---|---|
| *Lactarius ruginosus* | BRI, loc. Fraser Island | Likely misidentification of an indigenous species in natural habitats |
| *Lactarius subdulcis* | Fungimap, MEL2118486A, MEL2069101A, MEL2336349A, HO513643, BRI-AQ0811039, and literature reports | Likely misidentifications of indigenous species in the *L. eucalypti* group in natural habitats |
| *Lactifluus corrugis* | Duke University, loc. Northern Territories | Likely misidentification of an indigenous species in natural habitats |
| *Lactifluus luteolus* | BRI-AQ0798418, Queensland | Likely misidentification of an indigenous species in natural habitats |
| *Lactifluus piperatus* | Numerous records from widespread locations | Likely misidentification of an indigenous species in natural habitats |
| *Lactifluus volemus* | NYBG, Queensland | Likely misidentification of an indigenous species in natural habitats |
| *Multifurca furcata* | BRI-AQ0796297, Queensland | Misidentification of *M. stenophylla* indigenous species in natural habitats |
| *Russula adusta* | Numerous records from widespread locations and literature reports | Likely misidentifications of indigenous species (in the Compacta group) in natural habitats |
| *Russula alutacea* | MEL2367990A, Victoria | Likely misidentification of an indigenous species in natural habitats |
| *Russula cerolens* | Duke University, NZ Northland, Waikato & Bay of Plenty, with *Pinus* | Likely misidentifications of *Russula amoenolens* |
| *Russula cinereovinosa* (as *R. cinereopurpurea*) | NYBG, unlocalised | Likely misidentification of an indigenous species in natural habitats |
| *Russula compacta* | Numerous records from widespread locations and literature reports | Likely misidentifications of indigenous species (in the compacta group) in natural habitats |
| *Russula cyanoxantha* | Numerous records from widespread locations and literature reports | A widely misapplied name. Likely misidentifications of indigenous species in natural habitats |
| *Russula delica* | Several records from widespread locations and literature reports | Likely misidentifications of indigenous species (in the compacta group) in natural habitats |
| *Russula emetica* | Numerous records from widespread locations | A widely misapplied name. Likely misidentifications of indigenous species in natural habitats |
| *Russula foetens* | Numerous records from widespread locations and literature reports | A widely misapplied name. Likely misidentifications of indigenous species in natural habitats, such as *R. neerimea*, and/or species in the introduced Ingratula group |
| *Russula foetida* | Several records | Probable recording errors for *Russula foetens*, which see |
| *Russula fragrantissima* | NYBG, Western Australia | Likely misidentification of an indigenous species in natural habitats |
| *Russula grata* | Numerous records from widespread locations | Misapplication in eDNA data |
| *Russula integra* | Several records | Likely misidentifications of indigenous species in natural habitats and/or species in the introduced Ingratula group |

| Taxon | Data Source | Comment |
|---|---|---|
| *Russula mariae* | Several records from widespread locations and literature reports | Likely misidentification of an indigenous species in natural habitats |
| *Russula nigrescentipes* | BRI-AQ0795169, Queensland | Likely misidentification of an indigenous species in natural habitats |
| *Russula nigricans* | Several records | See the correct name *Russula adusta* |
| *Russula rosacea* | Several records, including iNaturalist Australia | The name has been generally used as a misapplication of *Russula sanguinaria*, but Australian records are likely misidentifications |
| *Russula rosea* | iNaturalist Australia | A misidentification |
| *Russula rubra* | BRI-AQ0812680, BRI-AQ0645914, Queensland, and literature reports | Likely misidentifications of an indigenous species in natural habitats |
| *Russula sanguinea* | iNaturalist Australia and literature reports | Likely misidentifications of an indigenous species in natural habitats |
| *Russula schaefferi* (as *Gymnomyces brunnescens*) | Harvard University, Tasmania | A misidentification of an indigenous species |
| *Russula violeipes* | Numerous records from widespread locations | Misidentifications in eDNA data |
| *Russula virescens* | iNaturalist Australia | Likely misidentifications of an indigenous species in natural habitats |
| *Russula xerampelina* | Several records, including iNaturalist Australia and literature reports | Likely misidentifications of an indigenous species in natural habitats |

**Appendix 2.** Sequence data used in the analysis. Newly generated sequences are highlighted in bold.

| Species | Collection/Fungarium number | Country of origin | ECM Host | GenBank/UNITE ITS accession number |
|---|---|---|---|---|
| *Lactarius acris* | GENT:BG2011-31 | Belgium | | KF432962 |
| *Lactarius aquosus* | GENT:KW 231 | Thailand | | KF432984 |
| *Lactarius asiae-orientalis* | KUN-HKAS 61370 Holotype | China | | MK253479 |
| *Lactarius atroviridis* | GENT:AV05-306 | USA | | KF133270 |
| *Lactarius atroviridis* | | USA | | KX389114 |
| *Lactarius circellatus* | KR-M-0044647 | Germany | | MT006008 |
| *Lactarius deliciosus* | | Algeria | | MT262921 |
| *Lactarius deliciosus* | MEL2101917 | Australia | *Pinus radiata* | **MZ519802** |
| *Lactarius deliciosus* | MEL2238310 | Australia | *Pinus radiata* | **MZ519800** |
| *Lactarius deliciosus* | MEL2257811 | Australia | *Ulmus* | **MZ519801** |
| *Lactarius deliciosus* | JET1021: MEL2238314 | Australia | *Pinus radiata* | **MZ519804** |
| *Lactarius deliciosus* | JET1017: MEL2238310 | Australia | *Pinus radiata* | **MZ519803** |
| *Lactarius deliciosus* | HKAS 94736 | China | *Pinus* | KY684167 |
| *Lactarius deliciosus* | | New Zealand | *Pinus pinea* | MT397068 |
| *Lactarius deliciosus* | | New Zealand | *Pinus radiata* | MT397070 |
| *Lactarius deliciosus* | | Portugal | | MG334288 |
| *Lactarius deliciosus* | GENT: JN 2001-046 | Slovakia | | KF133272 |
| *Lactarius deliciosus* | 2006 09 12 2 | UK | | JQ888181 |
| *Lactarius deterrimus* | KUN-HKAS 61943 | China | *Pinus armandii* | MK158321 |
| *Lactarius flexuosus* | GENT:RW2136 | Sweden | | KJ742400 |
| *Lactarius fuliginosus* | GENT:DS 06-310 | Belgium | | JQ446110 |
| *Lactarius glyciosmus* | TUF117427 | Estonia | | UDB031388 |
| *Lactarius glyciosmus* | E.Cautero 1315 | Italy | | JF908294 |
| *Lactarius glyciosmus* | JAC9222: PDD80997 | New Zealand | *Betula pendula* | **MW683723** |
| *Lactarius glyciosmus* | JAC16150: PDD113295 | New Zealand | *Betula* sp. | **MW683881** |
| *Lactarius glyciosmus* | O-F-260397 | Norway | | UDB036376 |
| *Lactarius hepaticus* | Hal-BP-102 | Italy | *Halimium halimifolium* | MT594520 |
| *Lactarius lignyotus* | GENT:KVP 08-083 | Austria | | JQ446113 |
| *Lactarius mammosus* | IK-00156 | Poland | | KX610693 |
| *Lactarius mammosus* | UPS: UE09.09.2004-5 | Sweden | | KF133265 |
| *Lactarius turpis* | MEL2257814 | Australia | *Betula pendula* | **MZ519806** |
| *Lactarius turpis* | JET1125: MEL2118493 | Australia | Nothofagaceae & *Eucalyptus regnans* | **MZ519805** |
| *Lactarius turpis* | MEL2369979 | Australia | *Betula* | **MZ519807** |
| *Lactarius necator* | | Denmark | *Fagus sylvatica* | AM087287 |
| *Lactarius necator* | TUB:hue203 | Finland | | AY606950 |
| *Lactarius necator* | ID PAN 744 | Poland | | KM085369 |
| *Lactarius olivaceoumbrinus* | UBCF23766 | Canada | | KC581315 |
| *Lactarius olivaceoumbrinus* | PU_1008 | India | *Abies* | KX845556 |
| *Lactarius orientaliquietus* | KUN-HKAS 61966 Holotype | China | | MH447589 |
| *Lactarius orientitorminosus* | TPML110928-063 Holotype | South Korea | *Quercus* | MH985020 |
| *Lactarius parallelus* | HCCN12093 Holotype | South Korea | | MH984953 |
| *Lactarius pseudodeceptivus* | Smith 71932 | USA | | MK931348 |
| *Lactarius pseudodelicatus* | MONT:CLC512 | USA | *Populus tremuloides* | KX394295 |
| *Lactarius pubescens* | MEL2151432 | Australia | *Betula pendula* | **MZ519810** |

| Species | Collection/Fungarium number | Country of origin | ECM Host | GenBank/UNITE ITS accession number |
|---|---|---|---|---|
| *Lactarius pubescens* | MEL2257969 | Australia | *Betula pendula* | **MZ519811** |
| *Lactarius pubescens* | JEich15: MEL2320720 | Australia | *Betula pendula* | **MZ519808** |
| *Lactarius pubescens* | MEL2096561 | Australia | *Betula pendula* | **MZ519809** |
| *Lactarius pubescens* | MEL2264835 | Australia | *Betula pendula* | **MZ519812** |
| *Lactarius pubescens* | MEL2379128 | Australia | *Betula pendula* | **MZ519814** |
| *Lactarius pubescens* | JEich15: MEL2320720 | Australia | *Betula pendula* | **MZ519813** |
| *Lactarius pubescens* | | China | *Ostryopsis davidiana* | JX129140 |
| *Lactarius pubescens* | TUB:hue135 | Germany | | AY606953 |
| *Lactarius pubescens* | JAC10930: PDD95387 | New Zealand | *Betula pendula* | **MW683764** |
| *Lactarius pubescens* | JAC16149: PDD113294 | New Zealand | *Betula* sp. | **MW683880** |
| *Lactarius pubescens* | JAC11787: PDD96184 | New Zealand | *Betula* sp. | **MW683793** |
| *Lactarius pubescens* | GENT:AV 96-931 | Norway | | AY336958 |
| *Lactarius pubescens* | MONT:EB300-15 | USA | | KX394296 |
| *Lactarius pubescens* | MONT:CLC539 | USA | *Populus tremuloides* | KX394297 |
| *Lactarius pyrogalus* | TAAM204056 | Estonia | | UDB015966 |
| *Lactarius pyrogalus* | JAC12115: PDD96354 | New Zealand | *Corylus avellana* | **MW683797** |
| *Lactarius pyrogalus* | O-F-260512 | Norway | | UDB037216 |
| *Lactarius pyrogalus* | O-F-22147 | Norway | | UDB035938 |
| *Lactarius quieticolor* | CONC-F 0810 | Chile | *Pinus radiata* | MT335833 |
| *Lactarius quieticolor* | GENT:RW&AV 3193 | Czech Republic | | KJ769676 |
| *Lactarius quieticolor* | | South Africa | | EF565902 |
| *Lactarius quietus* | GENT:KW131 | Belgium | | KF432972 |
| *Lactarius quietus* | JAC12929: PDD97029 | New Zealand | *Quercus* sp. | **MW683811** |
| *Lactarius quietus* | ID PAN 600 | Poland | | KM085389 |
| *Lactarius quietus* | UPS:UE16.09.2004 | Sweden | | KF133264 |
| *Lactarius rufus* | GENT:KW500 | Belgium | | KT165272 |
| *Lactarius rufus* | | Canada | | JQ711991 |
| *Lactarius rufus* | GENT:JN 2012-022 | Germany | | KT165276 |
| *Lactarius rufus* | JAC11466: PDD95865 | New Zealand | | **MW683782** |
| *Lactarius rufus* | PL233508 | New Zealand | | **MZ619132** |
| *Lactarius rufus* | K80S07 | New Zealand | *Pinus radiata* | GQ267478 |
| *Lactarius rufus* | GENT:KVP10-030 | Russia | | KT165277 |
| *Lactarius torminosus* | GENT:JN 2011-086 | Greece | | KR025613 |
| *Lactarius torminosus* | IZS81737/10-138 | Italy | | MZ005536 |
| *Lactarius torminosus* | CBS197.72 | Netherlands | | MH860447 |
| *Lactarius turpis* | JAC8818: PDD 79875 | New Zealand | *Betula pendula* | **MW683715** |
| *Lactarius turpis* | JAC15927: PDD 113074 | New Zealand | *Betula* sp. | **MW683866** |
| *Lactifluus vitellinus* | GENT:HTL 348 | Thailand | | HQ318251 |
| *Lactifluus volemus* | GENT:KVP 08-039 | Thailand | | HQ318245 |
| *Russula amoenolens* | MEL2193626 | Australia | *Quercus canariensis* | MZ519815 |
| *Russula amoenolens* | MEL2397790 | Australia | *Quercus* | MZ519816 |
| *Russula amoenolens* | MICH12838 | France | | KF245510 |
| *Russula amoenolens* | 2010BT118 | Germany | | KF318080 |
| *Russula amoenolens* | KR-M-0044645 | Germany | | MT005913 |
| *Russula amoenolens* | KR-M-0044213 | Germany | | MT005962 |
| *Russula amoenolens* | ET15M | Italy | *Quercus ilex, Pinus halepensis* | MW349690 |

| Species | Collection/Fungarium number | Country of origin | ECM Host | GenBank/UNITE ITS accession number |
|---|---|---|---|---|
| *Russula amoenolens* | JAC9208: PDD80990 | New Zealand | *Quercus robur* | **MW683721** |
| *Russula amoenolens* | JAC10961: PDD95417 | New Zealand | *Pinus* | **MW683769** |
| *Russula amoenolens* | PL 9111: PDD101435 | New Zealand | *Quercus* | **MZ619133** |
| *Russula amoenolens* | PDD103800 | New Zealand | *Pinus nigra* subsp. *laricio* | **MZ619135** |
| *Russula amoenolens* | JAC9273: PDD80743 | New Zealand | *Tilia* × *europaea* | **MW683725** |
| *Russula amoenolens* | CS R04: PDD77763 | New Zealand | | GU222264 |
| *Russula amoenolens* | JAC9217: PDD 80993 | New Zealand | *Pinus radiata* | **MW683722** |
| *Russula amoenolens* | PL4511 | New Zealand | | **MZ619136** |
| *Russula amoenolens* | PL121304: PDD 101436 | New Zealand | *Populus* | **MZ619134** |
| *Russula amoenolens* | | Poland | | MK583522 |
| *Russula amoenolens* | AH:46371 | Spain | *Quercus* sp. | MK105625 |
| *Russula amoenolens* | LUGO:ECC18051601 | Spain | *Quercus pyrenaica* | MW376706 |
| *Russula amoenolens* | 16N | Spain | *Eucalyptus nitens* | MK492607 |
| *Russula amoenolens* | 280 | Spain | *Eucalyptus globulus* | KY681463 |
| *Russula amoenolens* | 146 | Spain | *Castanea sativa* | MN663161 |
| *Russula amoenolens* | Lug14488 | Switzerland | | KJ834607 |
| *Russula amoenolens* | 115 | Switzerland | | KJ834590 |
| *Russula amoenolens* | TUB:nl27.9.95.6 | | *Quercus* | AF418615 |
| *Russula atrorubens* | | Slovakia | | MT908302 |
| *Russula atrorubens* | TU101718 | | | KX579812 |
| *Russula atrorubens* | TU106570 | | | KX579819 |
| *Russula atrorubens* | TU106421 | | | KX579817 |
| *Russula cerolens* | | Canada | *Quercus garryana* | KX449208 |
| *Russula cerolens* | | Canada | *Quercus garryana* | KX449182 |
| *Russula cerolens* | UBC:F18895 | | | HQ604833 |
| *Russula cerolens* | | | | HQ604832 |
| *Russula cessans* | MEL2359749 | Australia | *Pinus* | **MZ519819** |
| *Russula cessans* | MEL2293682 | Australia | *Pinus radiata* | **MZ519818** |
| *Russula cessans* | JET1080: MEL2238372 | Australia | *Pinus radiata* | **MZ519817** |
| *Russula cessans* | DMS-9333482 | Denmark | | MT644904 |
| *Russula cessans* | OSA:MY-7811 | Germany | | LC192757 |
| *Russula cessans* | 130732MFBPC626 | | | MW554164 |
| *Russula cessans* | 130732MFBPC599 | | | MW554172 |
| *Russula cf. amoenolens* | TENN:067119 | USA | *Tsuga* | KT933954 |
| *Russula cf. amoenolens* | | USA | | KX389121 |
| *Russula cf. amoenolens* | | | | JQ622327 |
| *Russula cf. nauseosa* | LT06 | China | | MN240852 |
| *Russula cf. nauseosa* | XYY02 | China | | MN240853 |
| *Russula cf. recondita* | F:PRL7415 | USA | *Quercus* | GQ166870 |
| *Russula cf. recondita* | NYBG:672053 | USA | | KF318046 |
| *Russula cf. recondita* | MI:6271 | USA | | KF318045 |
| *Russula cf. recondita* | | | | JQ622374 |
| *Russula cf. recondita* | | | | JQ622363 |
| *Russula cf. recondita* | | | | JQ622382 |
| *Russula emetica* | UBC F30056 | | | KX579781 |
| *Russula emetica* | UBC F30121 | | | KX579790 |

| Species | Collection/Fungarium number | Country of origin | ECM Host | GenBank/UNITE ITS accession number |
|---|---|---|---|---|
| *Russula emetica* | UBC F30123 | | | KX579792 |
| *Russula grisea* | SAV F-1395 | Slovakia | | MT738286 |
| *Russula grisea* | SAV F-1436 | Slovakia | | MT738287 |
| *Russula ionochlora* | 982_ITS1F_TUBE300908_ed | Germany | *Alnus* & *Quercus* | GQ924691 |
| *Russula ionochlora* | 978_ITS1F_ITS4_TUBE220708_ed | Germany | | GQ924690 |
| *Russula ionochlora* | JAC11808: PDD96205 | New Zealand | *Cedrus libani* | **MW683794** |
| *Russula ionochlora* | JAC11831: PDD96220 | New Zealand | *Quercus robur* | **MW683795** |
| *Russula ionochlora* | BB72_404_Ah_210507 | | *Fagus sylvatica* | HM189867 |
| *Russula ionochlora* | BB72_408_Bv_210507_R67 | | *Fagus sylvatica* | HM356007 |
| *Russula ionochlora* | BB72_403_Bv_210507_R15 | | *Fagus sylvatica* | HM189874 |
| *Russula laccata* | PDD101480 | New Zealand | *Salix* | **MZ619137** |
| *Russula laccata* | PDD101481 | New Zealand | *Salix* | **MZ619138** |
| *Russula laccata* | | Sweden | *Salix* | JQ724007 |
| *Russula laccata* | | Sweden | *Salix* | JQ724003 |
| *Russula laccata* | | Sweden | *Salix* | JQ724006 |
| *Russula laccata* | TU<EST>:101871 | | | KX812854 |
| *Russula nana* | TU101701 | Estonia | *Picea*, *Betula* & *Pinus sylvestris* | KX579809 |
| *Russula nana* | TUF101878 | Finland | *Betula* | UDB016029 |
| *Russula nana* | JAC10821: PDD95269 | New Zealand | *Salix caprea* | **MW683748** |
| *Russula nana* | JAC11191: PDD95650 | New Zealand | *Salix fragilis* | **MW683775** |
| *Russula nana* | | | | AY061694 |
| *Russula nauseosa* | GENT:FH-12-173 | Germany | | KT933985 |
| *Russula nitida* | PRM922555 | Czech Republic | | MG687360 |
| *Russula nitida* | KR:0004221 | Germany | | KU205349 |
| *Russula nitida* | PL232508: PDD101460 | New Zealand | *Betula* | **MZ619139** |
| *Russula nitida* | JAC9223: PDD80998 | New Zealand | *Betula pendula* | **MW683724** |
| *Russula nitida* | UPS:UE08.07.2004-2 | Sweden | | KU205269 |
| *Russula nitida* | WTU-F-073255 | USA | *Betula* | MW024889 |
| *Russula nitida* | PRM922543 | | | MG679818 |
| *Russula pectinata* | 2012BT30 | Germany | | KF318084 |
| *Russula pectinata* | 2010BT02 | Germany | | KF318081 |
| *Russula pectinatoides* | F1116010 | USA | | KU640187 |
| *Russula pectinatoides* | F1115989 | USA | | KU640188 |
| *Russula praetervisa* | MEL2238226 | Australia | *Quercus canariensis* | **MZ519820** |
| *Russula praetervisa* | 17220 | Italy | | KF303597 |
| *Russula praetervisa* | | Italy | | KF303598 |
| *Russula praetervisa* | 142 | Italy | | KJ530760 |
| *Russula praetervisa* | 12.065 | Morocco | | KJ530749 |
| *Russula praetervisa* | | | | MK327978 |
| *Russula recondita* | 4141 | Switzerland | | KJ530756 |
| *Russula recondita* | LUG:19058 Holotype | Switzerland | *Corylus maxima* 'Purpurea' | KJ530750 |
| *Russula sororia* | PRM 935984 | Czech Republic | | MG679815 |
| *Russula sororia* | LM1532 | UK | *Quercus robur* | KM576550 |
| *Russula sphagnicola* | PRM922122 | | | MG687324 |
| *Russula sphagnicola* | PRM922121 | | | MG687325 |

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# A mixed bag of sequestrate fungi from five different families: Boletaceae, Russulaceae, Psathyrellaceae, Strophariaceae, and Hysterangiaceae

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**Abstract:** We describe several new genera and species of sequestrate fungi from different regions of the world that belong to five different basidiomycete families. New taxa include: *Amylotrama gen. nov.*, *Amylotrama clelandii comb. nov.*, *A. banrockensis sp. nov.*, *Boletus kundabungkid sp. nov.* (Boletaceae), *Russula crassibasidiata sp. nov.*, *R. danksiae sp. nov.* (Russulaceae), *Statesia gen. nov.*, *Statesia cazaresii sp. nov.*, *S. zelleri sp. nov.*, *S. pompholyx comb. nov.*, and *S. calcarea comb. nov.* (Hysterangiaceae). We also confirm the placement of two blue-green species from Australasia, one that was previously placed in "*Le Ratia*" and the other in *Weraroa*, and make the new combination *Agrocybe smaragdina comb. nov.* (Strophariaceae), and describe *Coprinopsis pulchricaerulea sp. nov.* (Psathyrellaceae) accordingly.

**Keywords:** truffle-like fungi, taxonomy, *Le-Ratia*, *Leratiomyces*, Xerocomoideae

## Introduction

Numerous collections of sequestrate fungi have been made over the last 10 years in various parts of the world by the authors and other investigators. However, due to the cryptic habit (often hypogeal sporocarps) and patchy distribution of these fungi, many novel species are known from only one or a few collections. In the interest of advancing the taxonomy of these obscure and sometimes rare fungi, we provide descriptions and supporting data for several new taxa here. All of them are either from locations where fruiting is highly seasonal due to environmental conditions, thus rarely photographed or collected, or are unique in morphology and phylogenetic placement in genera that currently have no recorded sequestrate taxa.

In this paper we describe two new genera, seven new species, and make four new combinations for sequestrate (truffle-like) fungi from several different lineages. We utilise both molecular and morphological characters to determine their phylogenetic affinities with epigeal agaricoid, boletoid, or phalloid relatives.

## Methods

### *Morphology*

Macroscopic characters are based on examination of fresh material and field notes of dried collections. Colours are described in general terms. Fresh material was dried in a food dehydrator at 35°C for 12 h. Habitat, associated plant communities and fruiting season are based on field notes.

Hand-cut sections of fresh and dried material were either mounted in 5% aqueous solution of KOH, then stained with Congo red, or directly stained with Melzer's reagent. Measurements were made at ×400 or ×1000 with a calibrated ocular micrometer. Spore dimensions are given as length range × width range, mean ± standard deviation. The length:width ratio (Q) of individual spores is presented as the range of Q values and the $Q_{mean}$. Measurements do not include the apiculus. Dimensions of basidia and cystidia are given as length range × width range (n = 15). All drawings and illustrations are based on type material unless otherwise stated.

### *Molecular analyses*

***Taxon sampling.*** Based on preliminary blast searches of sequences generated for this study in GenBank and UNITE (Kõljalg *et al.* 2013), separate alignments were generated, with sequences representing a range of species within each lineage. Sister clade selection and appropriate reference outgroups for each lineage were based on various studies of each lineage (Matheny *et al.* 2006; Dentinger *et al.* 2010; Melzer *et al.* 2016; Vidal *et al.* 2019; Wachter & Melzer 2020). Names of taxa


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**Table 1.** GenBank numbers for sequences generated for new species and some related taxa. Newly generated sequences are in bold.

| Genus | Species | Herbarium# or collection# | Country | GenBank ITS | GenBank LSU | GenBank atp6 | GenBank tef1 |
|---|---|---|---|---|---|---|---|
| *Amylotrama* | *clelandii* | MEL2432546 | Australia | **MT007924** | **MT459235** | - | **MN413630** |
| *Amylotrama* | *clelandii* | AD-C58886 | Australia | **MT007927** | **MN393698** | - | **MN413634** |
| *Amylotrama* | *clelandii* | AD-C58782 | Australia | **MT007929** | - | - | **MN413631** |
| *Amylotrama* | *clelandii* | MEL2464313 | Australia | **MT007928** | - | - | **MN413632** |
| *Amylotrama* | *clelandii* | MEL2464387 | Australia | **MT007926** | - | - | **MN413633** |
| *Amylotrama* | *banrockensis* | AD-C58672 | Australia | MT703615 | - | - | **MN413637** |
| *Boletus* | *edulis* | MEL2363164 | Australia | **MZ997390** | **MZ997376** | - | - |
| *Boletus* | *kundabungkid* | MEL2417154 | Australia | **MZ997388** | **MZ997377** | **OK235707** | **OK323368** |
| *Boletus* | *semigastroideus* | PDD95796 | New Zealand | **MZ997389** | - | - | - |
| *Russula* | *crassibasidiata* | MEL2364422 | Australia | **MT893301** | **MT893304** | - | - |
| *Russula* | *crassibasidiata* | MEL2364389 | Australia | **MT893302** | **MT893305** | - | - |
| *Russula* | *crassibasidiata* | MEL2364390 | Australia | **MT893300** | **MT893307** | - | - |
| *Russula* | *danksiae* | MEL2363642 | Australia | **MT893298** | **MT893306** | - | - |
| *Russula* | *danksiae* | OSC H5934 | Australia | **MT893299** | **MT893303** | - | - |
| *Russula* | *danksiae* | MEL2363640 | Australia | **MT913007** | - | - | - |
| *Coprinopsis* | *pulchricaerulea* | MEL2363910 | Australia | **MZ997378** | **MZ997371** | - | - |
| *Coprinopsis* | *pulchricaerulea* *2nd basidiome | MEL2363910 | Australia | **MZ997381** | - | - | - |
| *Coprinopsis* | *pulchricaerulea* | MEL2363909 | Australia | **MZ997379** | **MZ997372** | - | - |
| *Coprinopsis* | *pulchricaerulea* | MEL2363911 | Australia | **MZ997380** | **MZ997373** | - | - |
| *Coprinopsis* | *pulchricaerulea* | MEL2305158 | New Caledonia | **MZ997383** | **MZ997374** | - | - |
| *Coprinopsis* | *pulchricaerulea* | MEL2305157 | New Caledonia | **MZ997384** | **MZ997375** | - | - |
| *Coprinopsis* | *pulchricaerulea* | MEL2363908 | Aus: Lord Howe Is | **MZ997382** | - | - | - |
| *Coprinopsis* | sp. | MEL2409229 | Australia | **MZ997387** | - | - | - |
| *Agrocybe* | *smaragdina* | MEL2305149 | New Caledonia | **MZ997385** | - | - | - |
| *Agrocybe* | *smaragdina* | TNS-F-34123 | New Caledonia | **MZ997386** | - | - | - |
| *Agrocybe* | *smaragdina* | TNS-F-33732 | New Caledonia | **OK147735** | **OK147739** | - | - |
| *Agrocybe* | *smaragdina* | TNS-F-34162 | New Caledonia | **OK147736** | - | - | - |
| *Statesia* | *calcarea* | OSC159163 | Germany | - | - | DQ218776 | DQ219149 |
| *Statesia* | *cazaresii* | OSC159158 | Mexico | - | - | DQ218849 | DQ219180 |
| *Statesia* | *pompholyx* | OSC Gross495 | France | - | - | DQ218783 | DQ219163 |
| *Statesia* | *zelleri* | OSC159159 | United States | - | - | DQ218854 | DQ219185 |

in phylogenies are as they currently appear in GenBank (i.e. not updated taxonomically).

For **Boletaceae**, six alignments were generated. A concatenated TEF1-α and LSU alignment with *Amylotrama gen. nov.* and related taxa of Xerocomoideae (subfamily of Boletaceae), with a *Suillus* exemplar as outgroup, consisted of 2107 sites (1202 sites for the TEF1-α portion of the alignment, 905 sites of the LSU portion). This alignment was analysed to confirm subfamily placement. Since only a limited number of specimens of *Amylotrama* were available from which both loci were retrieved, only a TEF1-α alignment with additional specimens of *Amylotrama* was analysed; the subsequent phylogenetic tree from this analysis is presented here. Partial ITS sequences were also retrieved for *Amylotrama*. For *Boletus kundabungkid sp. nov.*, four separate single gene analyses (ITS, LSU, TEF1-α, atp6)

were performed, all of which corroborated the new species, however we were unable to obtain sufficient sequences of multiple loci across exemplars to produce a concatenated alignment. Thus, we present only the results from the TEF1-α alignment consisting of 604 sites, with *Tylopilus* as outgroup, as the best overall representation of placement.

For **Russulaceae** the alignment included closely related taxa in *Russula* subg. *Heterophyllidiae* sect. *Ingratae* and consisted of 1504 sites (847 sites for LSU, 657 sites for ITS), with *Lactarius* cf. *luculentus* Burl. as outgroup.

For **Psathyrellaceae** the concatenated ITS and LSU alignment representing a selection of sections within *Coprinopsis*, with *Parasola conopilea* (Fr.) Örstadius & E. Larss. as outgroup, consisted of 1448 sites (632 sites for ITS, 816 for LSU).

For **Strophariaceae** the ITS alignment including representative *Agrocybe*, *Psilocybe*, *Keuhneromyces* and *Protostropharia* species, with *Pholiota terrestris* Overh. as outgroup, consisted of 623 sites.

For **Hysterangiaceae** the concatenated ATP6 and TEF1-α alignment representing *Statesia gen. nov.* and related taxa, with *Geastrum fornicatum* (Huds.) Hook. as outgroup, consisted of 1387 sites (688 sites for ATP6, 699 sites for TEF1-α).

Novel sequences representing collections from Australasia and other regions generated for this study are listed in Table 1 with relevant GenBank accession numbers.

***Nucleic acid preparation, amplification and sequencing.*** Genomic DNA was isolated with an E.Z.N.A. forensic DNA kit (Omega Biotek) for samples older than 1995, or the QIAGEN DNeasy Plant Mini Kit, following the manufacturer's protocol. The targeted regions were amplified from purified DNA with standard fungal primer pairs ITS1/ITS4 (White *et al.* 1990; Gardes & Bruns 1993); LROR/LR5 (Hopple & Vilgalys 1994); and ef1-983f/ef1-1567r (Binder & Hibbett 2003; Rehner & Buckley 2005) or atp6-1/atp6-2 (Kretzer & Bruns 1999). PCR protocols followed standard methods (Lebel & Tonkin 2007; Danks *et al.* 2010; Lebel & Syme 2012; Lebel *et al.* 2015; Davoodian *et al.* 2021). Assembly and manual editing of sequences for each region were performed with Geneious 9.1.3 (Biomatters Ltd).

***Phylogenetic analyses.*** Analyses were performed with RAxML 8.2.12 (Stamatakis *et al.* 2014) and Bayesian likelihood with the Metropolis coupled Markov chain Monte Carlo (MCMC) search algorithm implemented in MrBayes 3.2.5 (Ronquist & Huelsenbeck 2003). Gaps in alignments were treated as missing data. Modeltest (Posada & Crandall 1998) was used to determine appropriate evolutionary models for the Bayesian analyses. Each search involved four chains (three heated to 0.2 and one cold) sampled every 1000 generations. The search ran until convergence between runs was achieved, measured by a standard deviation of split frequencies below 0.05 and observing when this was no longer decreasing. After discarding burn-in, consensus trees or ML trees were imported to FigTree 1.4.2 (Rambaut 2009) and are presented with posterior probabilities or ML bootstrap values at clades.

### *Nomenclature*

Registration numbers are provided for new and existing names (with prefixes MB = MycoBank or IF = Index Fungorum) and new typifications (prefix MBT = MycoBank typification).

## Results & Discussion

Single gene analyses were performed using Bayesian and Maximum likelihood approaches, and the same key relationships were recovered in all analyses. Where possible, concatenated alignments were analysed. However, in some cases there were insufficient sequences of multiple genes to produce a concatenated alignment; in these instances we present well supported single gene data.

## Taxonomy

### **Boletaceae** Chevall.

The family Boletaceae is a diverse, mostly ectomycorrhizal lineage which associates with a broad range of plant families. In the last decade, with the advent and expansion of molecular techniques, taxon concepts in the family have been revised considerably with the recognition of seven major clades at subfamily level and at least 62 generic lineages, and numerous new species have been described (Nuhn *et al.* 2013; Halling *et al.* 2014; Wu *et al.* 2014, 2016; Gelardi *et al.* 2015; Vadthanarat *et al.* 2019, 2021; Raghoonundon *et al.* 2021). The sequestrate habit has arisen multiple times and a large number of sequestrate genera have been described (Desjardin *et al.* 2009; Trappe *et al.* 2013; Castellano *et al.* 2016; Orihara *et al.* 2016; Orihara & Smith 2017; Crous *et al.* 2018; Vadthanarat *et al.* 2019). In Australia, taxonomic and phylogenetic revision of sequestrate Boletaceae is in its infancy, with many undescribed taxa to resolve.

### ***Amylotrama*** Bloomfield, Davoodian, Trappe & T.Lebel, ***gen. nov.***

**Typus:** *Amylotrama clelandii* (G.Cunn.) Bloomfield, Davoodian, Trappe & T.Lebel

**Registration identifier: IF557864.**

*Basidiomata* subglobose, vaguely reniform, to irregular, 20–35 mm diam., 11–20 mm high; surface dry, cream to yellow to dull or dingy yellow, with either thin filamentous dark patches or gray rough patches; at times

**Key to sequestrate Boletaceae mentioned in this paper and one unrelated but easily confused species**

**1.** Basidiomes with a robust stipe to 20 mm long, 10 mm diam., in association with *Leptospermum* spp.; found in New Zealand . . . . . ***Boletus semigastroideus***

**1:** Basidiomes lacking a stipe-columella or with a narrow < 1 mm diam. strand, in association with *Eucalyptus* spp.; found in Australia

**2.** Basidiomes cream to dull yellow to yellow with either thin, filamentous darker patches that are easily rubbed off or overlying irregular gray filamentous rough patches, tramal hyphae amyloid, spores inamyloid

**3.** Basidiomes become darker upon handling; pileipellis a thin undifferentiated cutis; spores 6.5–8.5 (–10.5) × 4.5–6.5 µm; basidia abundant, persistent, forming a conspicuous hymenial layer . . . . . 1. ***Amylotrama clelandii***

**3:** Basidiomes not darkening upon handling; pileipellis wide and distinctly two-layered; spores slightly larger, 8.0–10 µm × 5.5–7.2 µm; basidia readily collapsing, not forming a persistent hymenial layer . . . . . 2. ***Amylotrama banrockensis***

**2:** Basidiomes white to pale cream, either smooth without overlying patches or with fine pale brown fibrils, tramal hyphae inamyloid, spores dextrinoid

**4.** Hymenophore initially pale cream becoming pale olive green, spores 15–19 × 6–7 µm . . . . . ***Lepiota geogenia*** [Agaricaceae]

**4:** Hymenophore remaining pale cream or becoming ochraceous, spores broader 12–15 (–17) × 8–11.5 (–13) µm . . . . . 3. ***Boletus kundabungkid***

with rhizoids or basal attachment. *Hymenophore* cream to dull yellow to yellow to gray, at times oozing a clear liquid; loculate with chambers 2–4 mm wide, chambers may be more compressed towards the pileipellis. *Columella* present or absent; if present, white.

*Pileipellis* a thin cutis of dark yellow hyphae overlying a context composed of tangled, hyaline to pale yellow hyphae. *Hymenophoral trama* hyaline to yellowish, amyloid in Melzer's reagent. *Spores* statismosporic, hyaline to yellowish, subglobose to subovate, 6.5–10 × 4.5–7.2 µm, inamyloid, sometimes displaying oily inclusions. *Clamp connections* absent in all tissues.

***Notes.*** The name "*Amylotrama*" appears in herbaria and various publications as a provisional name applied to a polyphyletic assemblage of sequestrate boletoid fungi, with amyloid hymenophoral and/or pileal context trama in Melzer's reagent. Here we formally introduce the name *Amylotrama*, restricting it to one of these monophyletic clades, and describe two species based on morphological and DNA data (Fig. 2). BLAST searches of TEF1-α, ITS and LSU and phylogenetic analyses of the loci singly and concatenated strongly support placement of *Amylotrama* in the Xerocomoideae. The portions of ITS sequences retrieved were insufficient to discriminate between species within *Amylotrama*, however they suggested subfamily placement in Xerocomoideae, with BLAST searches matching several Xerocomoideae sequences lodged in GenBank at 92–95% (e.g. GenBank: KP012700, *Hemileccinum* sp. from northern Australia; MF686530, *Heimioporus betula* from U.S.A.). Thus far, ITS sequences have not matched any sequences from root tips based on searches of GenBank and UNITE, though 97–98% matches have been detected in Australian soil metagenomic ITS1 data (Davoodian *et al.* 2020). *Amylotrama* is the only sequestrate member of the Xerocomoideae described from Australia thus far, and the sequestrate habit is uncommon worldwide in this subfamily (Trappe & Castellano 2000).

Morphologically, *Amylotrama* exhibits coloration and general appearance more or less consistent with other Xerocomoideae, however no other Xerocomoideae exhibits amyloid trama. A direct comparison is difficult to make since almost all known Xerocomoideae are epigeous bolete mushrooms. *Gastroboletus vividus* Trappe & Castellano, a hypogeous to subhypogeous bolete with sequestrate basidiomes that occurs in the western United States, may be in Xerocomoideae based on our preliminary analysis of one LSU sequence (GenBank: KF030245).

*Amylotrama* can be distinguished from other Australian boletoid sequestrate genera by the combination of small basidiomata, cream to yellow to gray hymenophore, amyloid trama, and inamyloid subglobose to subovate spores.

***Etymology.*** The genus name refers to the amyloid reaction of the trama in Melzer's reagent.

### 1. *Amylotrama clelandii* (G.Cunn.) Bloomfield, Davoodian, Trappe & T.Lebel, *comb. nov.*

**Registration identifier: IF557865.**

*Rhizopogon clelandii* G.Cunn., *Proc. Linn. Soc. New South Wales* 59: 162 (1934), as "*clelandi*". MB374407. — *Alpova clelandii* (G.Cunn.) G.W.Beaton, Pegler & T.W.K.Young, *Kew Bull.* 40: 578 (1985). MB105028.

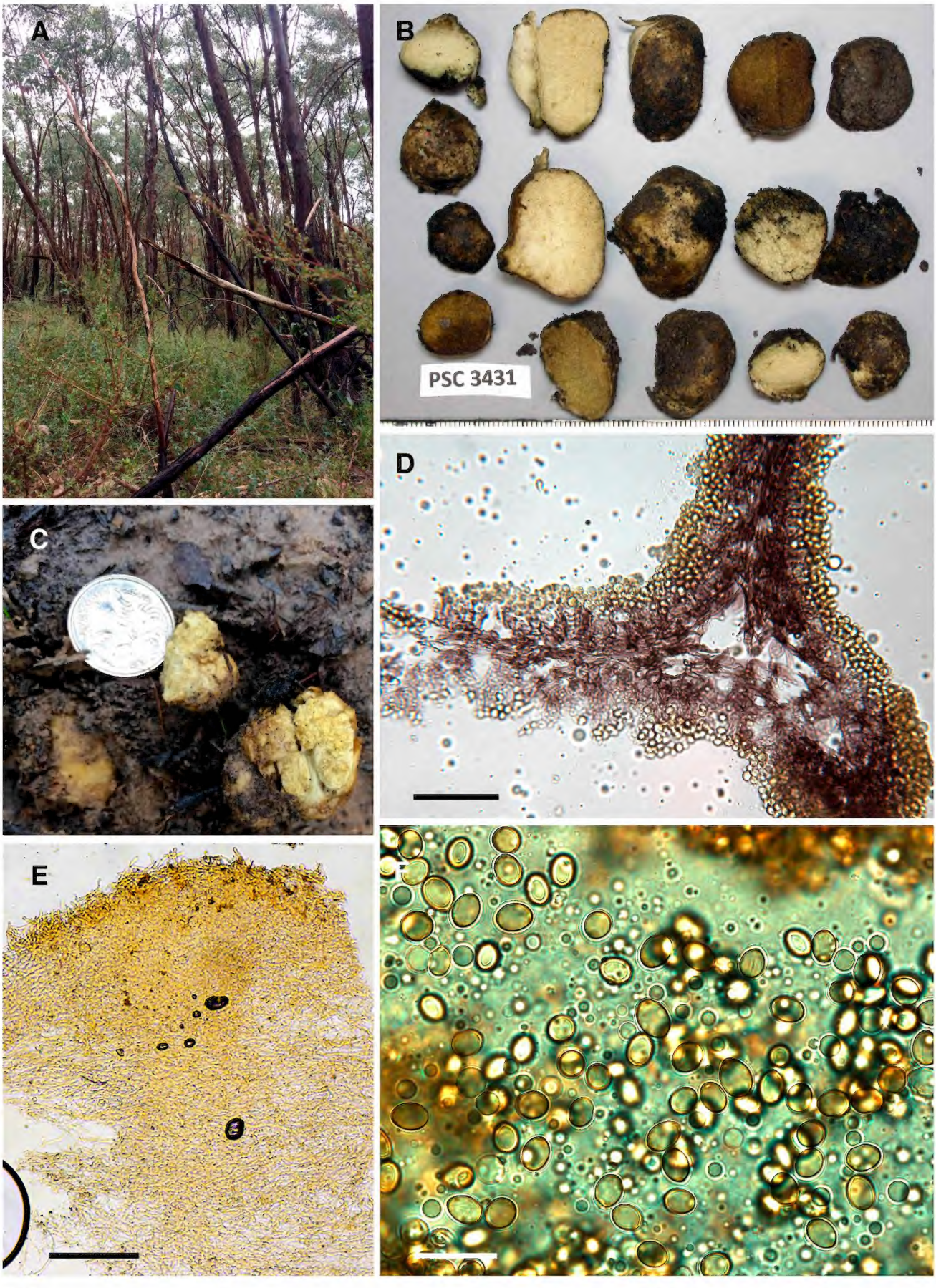


**Fig. 1.** *Amylotrama clelandii*. **A** Habitat image from epitype locality; **B** basidiomata fresh; **C** basidiomata *in situ*; **D** hymenophore tissue in Melzer's showing spores, basidia, basidioles, and amyloid subhymenial and tramal elements; **E** section of pileipellis and context through to the edge of the hymenophoral trama; **F** spores. Scale bars: D = 60 µm, E = 100 µm, F = 25 µm. — C–E *S.J.M. McMullan-Fisher 3140* (MEL2432546, epitype); B *P.S. Catcheside 3431* (AD-C58782). Photo: D. Catcheside (B).

— **Lectotype:** Australia, South Australia: Second Valley Forest Reserve, 6 June 1930, *J.B. Cleland s.n.* (AD-C58527; former accession number: ADW6009), *fide* G.W.Beaton, Pegler & T.W.K.Young, *Kew Bull.* 40: 579 (1985), as "holotype". **Epitype (here designated, MBT10003199):** Australia, South Australia: Mount Barker, Totness Recreation Park, 18 June 2018, *S.J.M. McMullan-Fisher 3140* (MEL2432546).

*Basidiomata* subglobose to elongate or reniform, sometimes lobed, becoming irregular, 20–35 mm diam., 11–20 mm high; surface dry when fresh, cream to dull yellow to yellow, becoming darker upon handling, with thin, filamentous darker patches that are easily rubbed off, drying tawny-brown; basal rhizoids rare (initially concolorous, becoming dark). *Hymenophore* cream to dull yellow to yellow, drying yellowish to tawny brown; loculate, empty, subglobose to irregular locules, up to 1–2 mm wide, locules occasionally more compressed towards the pileipellis. *Stipe* absent. *Columella*, when present, a percurrent narrow strand < 0.5 mm wide, white. *Odour* mild. *Taste* nondescript.

*Pileipellis* a thin layer 15–35 µm wide, composed of a patchy layer of dark yellow, interwoven hyphae 5.5–8.5 µm diam., easily missed in sectioning. *Context* 730–1000 µm wide, of hyaline to yellowish, septate hyphae, 2.5–5.0 µm diam., tangled and periclinal. *Hymenophoral trama* comprised of elongated, hyaline hyphae, 2.0–5.0 µm diam., and isodiametric subhymenial cells, the whole layer amyloid in Melzer's reagent. *Basidia* 28–36 × 9–11.5 µm, mean = 30.6 × 9.9 µm, abundant, persistent, forming a conspicuous hymenial layer, hyaline, sterigmata 2–4, 2.5–5 × 1–2.5 µm in size. *Spores* 6.5–8.5 (–10.5) × 4.5–6.5 µm, mean = 7.6 × 5.7 µm, Q = 1.1–1.7, $Q_{mean}$ = 1.3, statismosporic, hyaline, smooth, subglobose to slightly elongated to subovate, inamyloid, usually with conspicuous oily inclusions, moderately thick-walled. **Fig. 1.**

***Diagnosis.*** Distinguished from *Amylotrama banrockensis* by the poorly developed, thin pileipellis, slightly smaller spores, presence of persistent basidia and conspicuous hymenial layer, and smaller isodiametric cells in the subhymenium.

***Ecology & distribution.*** *Amylotrama clelandii* is thus far recorded as occurring solitarily or in small groups, hypogeous or emergent, in association with *Eucalyptus* spp. in south-eastern South Australia and southern Tasmania (collected in association with *Eucalyptus obliqua* at the epitype locality).

***Notes.*** *Rhizopogon clelandii* G.Cunn. (originally as "*clelandi*") was described by Cunningham (1934) from three collections of sequestrate fungi made by J.B. Cleland in June 1930 from Second Valley Forest Reserve in South Australia and held in Cleland's herbarium at the University of Adelaide. No accession numbers were cited in the protologue. Cleland's collections of macrofungi are now in AD, having been placed for a period in ADW (Waite Institute, University of Adelaide). Since no explicit type was specified, all three collections are syntypes. The Cleland material from Second Valley, currently at AD and identified originally as *R. clelandii*, is in two packets: AD-C58527 (formerly ADW 6009, collected 6 June 1930) and AD-C58528 (formerly ADW 6010). Within the latter packet, two collections made on different dates have been separated as AD-C58528A (4 June 1930) and AD-C58528B (6 June 1930). Beaton *et al.* (1985) cited the type as "Second Valley Forest Res., 5 June 1930, Cleland, Waites [sic] Agric. Inst. 6009 (holotype ADW 6009)". Although the date is incorrectly cited as 5 June, ADW 6009 corresponds to AD-C58527, which is the packet currently at AD that has not been subsequently divided. Grgurinovic (1997) cited the combined ADW 6010 collection but made no comment about typification. Because the existing collections are syntypes, and therefore a lectotype must be chosen, the designation by Beaton *et al.* (1985) of a "holotype" can be corrected to lectotype, following Article 9.10 of the *International code of nomenclature* (Turland *et al.* 2018). There is also a collection in the Landcare Research Fungarium (PDD) made by J.B. Cleland from Second Valley labelled "isotype of *Rhizopogon clelandii*" (PDD 8286) but the collection date is given only as June 1930, which means it is not clear which of the three AD collections it is a duplicate of.

Our molecular evidence supports the differentiation of two taxa, based upon data from recent collections (Fig. 2). The recent, sequenced collections of these two taxa also differ in some morphological features, in particular the width and differentiation of the pileipellis, the persistence of basidia and the presence of highly inflated cells in the subhymenium. Unfortunately, the original Cleland material of *Rhizopogon clelandii* (AD-C58527 and AD-C58528) is degraded, both for DNA (we were unsuccessful in obtaining sequences), and morphologically (e.g. collapsed spores, ruptured cells), preventing clear visualisation of features beyond the generic level. Based on morphological examination of the syntypes, we could not ascertain features that differentiate recent collections we have assigned to *A. clelandii* or *A. banrockensis*. Therefore it is necessary to select an epitype, above. Linking the recent, sequenced epitype to the lectotype solidifies the morphological and molecular interpretation of *A. clelandii*. Given the potential for the residual syntypes to represent *A. banrockensis*, we choose to leave them identified at the genus level only. In time, once the distribution of the two species is better understood, it may be possible to assign them to species based on locality and/or ecology.

### *Additional material examined*

**AUSTRALIA.** SOUTH AUSTRALIA: **Kangaroo Island.** Flinders Chase, nr Platypus Waterholes Walk from Shackle Rd, 25 June 2017, *T. Lebel 2898* (MEL2464387); Flinders Chase, nr Rocky River Heritage Accommodation (off Cape du Couedic Rd), past heath into woodlands, 25 June 2016, *T. Lebel 2804* (MEL2464313); Flinders Chase, off W side of

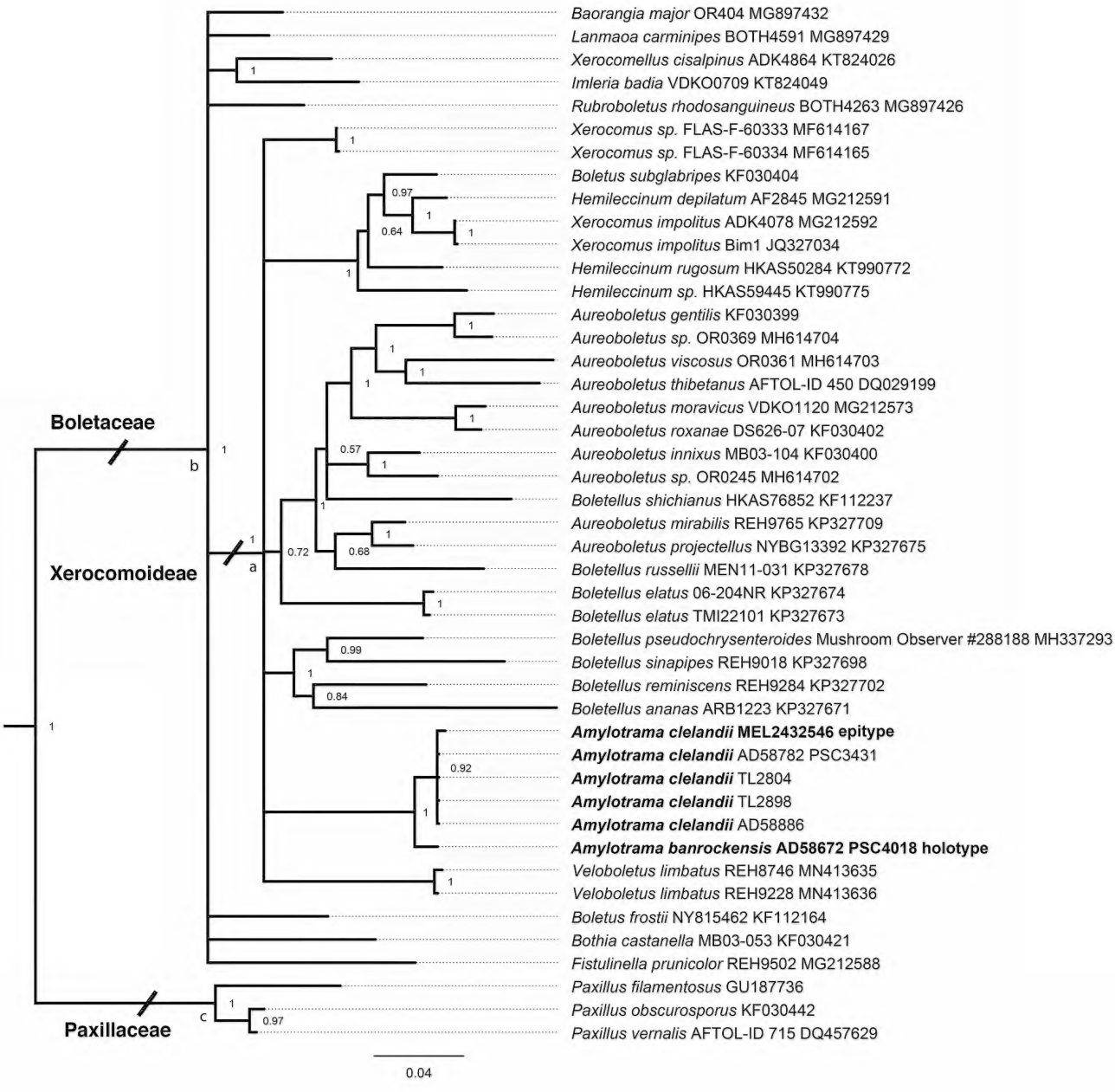


**Fig. 2.** Phylogram from Bayesian analysis of partial TEF1-α sequences. Scale bar shows substitutions per site. Bayesian posterior probabilities (bpp) are shown at the nodes. Thickened lines indicate PP support ≥ 0.95. Included in the analysis but cropped from the image are sequences from four *Suillus* species (KU721557, KU721631, KU721709, KU721719); *Suillus sinuspaulianus* (KU721557) was specified as the outgroup. Xerocomoideae (node a), Boletaceae (node b), and Paxillaceae (node c, sister to Boletaceae) are indicated.

trail loop, 24 June 2014, *P.S. Catcheside 3985* (AD-C58886); Flinders Chase, nr Rocky River, 28 May 2010, *P.S. Catcheside 3431* (AD-C58782)

TASMANIA. Huon Valley, Garden Island Creek, 3 June 2000, *G.M Gates & D.A. Ratkowsky EB26* (MEL2360433).

### *Residual syntypes of* A. clelandii, *identifiable only as* Amylotrama *sp.*

**AUSTRALIA.** SOUTH AUSTRALIA. Second Valley Forest Reserve, 4 June 1930, *J.B. Cleland ADW 6010* (AD-C58528A); Second Valley Forest Reserve, 6 June 1930, *J.B. Cleland ADW 6010* (AD-C58528B).

### 2. *Amylotrama banrockensis* Bloomfield, Davoodian & T.Lebel, *sp. nov.*

**Holotypus:** Australia, South Australia: Banrock Station, Loxton Waikerie, 11 July 2014, *D. Catcheside, C. Tourenq, T. Field & P.S. Catcheside 4018* (AD-C58672).

**Registration identifier: MB832366.**

*Basidiomata* subglobose or vaguely reniform, slightly indented at base, 30 × 24 × 20 mm; surface dry when fresh, with irregular gray to dark brown filamentous rough patches overlying smooth dingy yellow pellis, rhizomorphs absent or rare across pellis or at base. *Hymenophore* grey to yellow with very slight olive tinge,

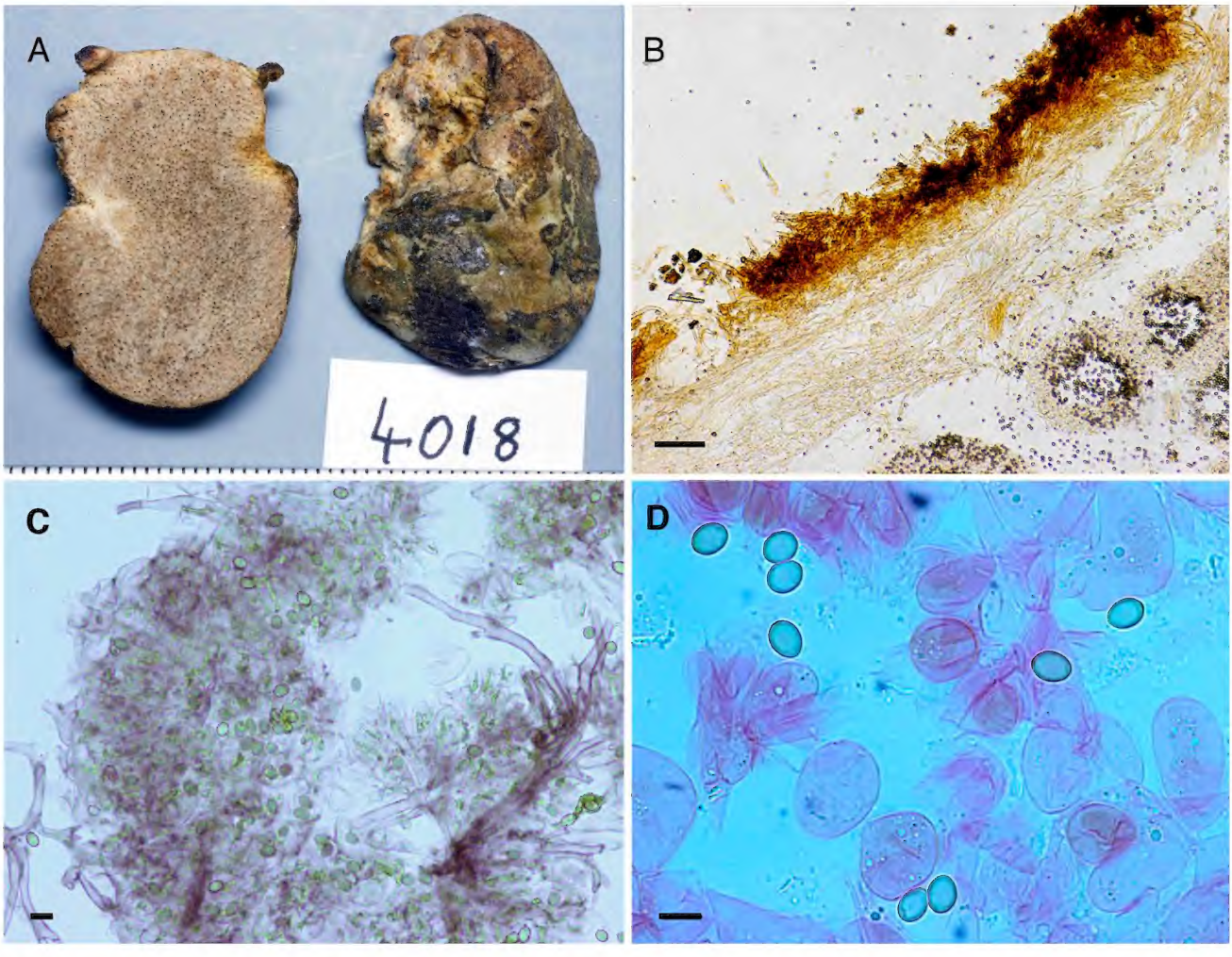


**Fig. 3.** *Amylotrama banrockensis*. **A** Basidiomata fresh; **B** section of pileipellis showing mixed suprapellis and subpellis, and context (in 3% KOH); **C** hymenophoral tissue showing amyloid inflated subhymenium elements, amyloid tramal tissues, and inamyloid spores (in Melzer's reagent); **D** spores, basidia, and inflated subhymenial elements (in phloxine). Scale bars: B–C = 50 µm, D = 10 µm. — A–C *D. Catcheside et al. 4018* (AD-C58672, holotype). Photo: D. Catcheside (A).

oozing clear liquid when squeezed; loculate, locules 2–3 mm, rounded. *Columella*, when present, small, not percurrent, slightly dendroid, extending 5 mm into basidiome, white. *Odour* of aniseed (in recent, dry material). *Taste* not recorded.

*Pileipellis* two-layered: a subpellis layer 70–180 µm wide, clearly differentiated from context, composed of golden brown hyphae, 5.4–12 µm diam., that are tangled and more or less periclinal, with obtuse apices; and overlying suprapellis, 20–65 µm wide, scattered in broad patches, composed of dark brown to greyish-brown filamentous septate hyphae, 6–14 µm diam., apices obtuse, partially erect to more or less flat, interwoven with subpellis hyphae. *Context* 215–430 µm wide, composed of hyaline to yellowish hyphae, 3–6 µm diam., mostly parallel. *Hymenophoral trama* hyaline to yellowish, composed of interwoven hyphae, 3–8 µm diam., and inflated to collapsing subhymenial cells, 12–31 × 9–26 µm diam., the whole layer amyloid in Melzer's reagent. *Basidia* 24–36 × 5–13 µm, narrowly clavate, thin-walled, hyaline, readily collapsing, few observed; sterigmata 2–4, 3–4 µm long. *Spores* 8.0–10.0 × 5.5–7.2 µm, mean = 8.98 × 6.61 µm, Q = 1.19–1.46 (–1.54), $Q_{mean}$ = 1.36, statismosporic, hyaline to yellow-hyaline, smooth, subglobose (sometimes slightly elongated) to subovate, inamyloid, some spores displaying oily inclusions. **Fig. 3.**

***Diagnosis.*** Distinguished from *Amylotrama clelandii* by the distinct differentiation of the wide two-layered pileipellis and context, slightly larger spores with a yellow tinge, lack of persistent basidia, highly inflated cells in the subhymenium, and aniseed odour when dried.

***Ecology & distribution.*** Occurs solitarily in South Australia and Victoria, hypogeous to erumpent, in South Australia with *Eucalyptus camaldulensis* and *E. largiflorens* with Chenopodiaceae shrubby understory in the River Murray floodplain, with *Eucalyptus* sp. on Kangaroo Island, and in Victoria with *E. globulus*.

***Notes.*** The aniseed odour was perceived by us in the holotype of *A. banrockensis*, which was collected and dried relatively recently (seven years ago). According to Cunningham (1934), "Although [*Rhizopogon clelandii*] is apparently without smell when fresh (according to the collection notes of Dr. Cleland), herbarium specimens

have a strongly aromatic odour as of aniseed." However, such an odour is no longer detectable for any of the three Cleland collections originally identified as *R. clelandii* at AD. Further observations on fresh collections are required to ascertain if the aniseed odour is characteristic of *A. banrockensis* and if it can be detected in collections confirmed as *A. clelandii*. The collection *Beaton 32* from Victoria identified here as *A. banrockensis* was listed by Beaton *et al.* (1985) under *Alpova clelandii*; we place it under *A. banrockensis* based on morphology (presence of highly inflated subhymenial cells, lack of persistent basidia, amyloid trama, appearance of the spores, and pileipellis structure).

Morphologically, the highly inflated cells in the subhymenium, more obviously two-layered pileipellis and slightly larger spores enable differentiation of *A. banrockensis* from the more widespread *A. clelandii*. Our molecular analysis also supports *A. banrockensis* as distinct from *A. clelandii* (Fig. 2), with TEF1-α sequences diverging by 2–3%. Given the current distribution, the most likely areas to search for more material of this taxon would appear to be in eastern South Australia and Western Victoria.

***Etymology.*** The specific epithet refers to the Banrock Station area, where the type was collected.

***Additional material examined.***

**AUSTRALIA.** VICTORIA. Colac-Otway, Grey River Reserve Rd, Kennett River, 3 July 1982, *G. Beaton 32* (MELU-F103764a).

### 3. *Boletus kundabungkid* T.Lebel, K.Syme & Davoodian, *sp. nov.*

**Holotypus:** Australia, New South Wales: North of Grassy Head, Yarrahapinni State Forest, 20 Nov. 2015, *I. Dodd s.n.* (MEL2417154).

**Registration identifier: MB841360.**

*Basidiomata* depressed globose or sub-turbinate, 10–18 mm tall, 10–25 mm diam., apex convex to occasionally planoconvex, base abruptly truncated, slightly excavated; white to pale cream coloured, drying pale tan, smooth, slightly viscid, sometimes irregularly areolate. *Stipe* highly reduced, 5–9 mm long, 2–5 mm diam., sharply tapering to base, at first white, becoming pale greyish or ochraceous, smooth, dry, cartilaginous in texture, barely inserted into hymenophore; context white, centrally hollow in some basidiomes. *Hymenophore* densely loculate, locules irregular in shape, less than 0.5 mm diam., empty, very pale cream initially becoming pale tan. No staining observed. *Odour* not distinctive. *Taste* mild.

*Pileipellis* composed of two layers, outer layer 80–175 µm thick, composed of septate hyphae, 4.5–7.2 µm diam., partly gelatinized and arranged in a vertical palisade 70–110 µm thick, the terminal elements are chains of inflated, globose to broadly clavate cells 19–48 µm long, 22–45 µm diam.; inner layer of hyaline, septate, interwoven hyphae 4.0–9.2 µm diam., to 200 µm thick, firm and compact. *Hymenophoral trama* 20–50 µm thick, pseudoparenchymatous, cells 5–11 × 5–9 µm. *Basidia* 23–40 × 12–15 µm, clavate to cylindrical, thin-walled, hyaline, 4-spored, embedded in a layer of obclavate to broadly clavate, thin-walled basidioles 16–24 × 10–17 µm. *Spores* (11.5–) 12–15 (–17) × 8–11.5 (–13) µm, mean = 13.83 ± 1.44 × 9.44 ± 1.2 µm (n = 40), Q = 1.2–1.8, $Q_{mean}$ = 1.43, ovate-elliptical or ovate-fusiform, irregular in size and shape, bluntly acuminate or rounded, base bluntly pointed, apiculate, pallid ferruginous, smooth, wall 1 µm thick, strongly dextrinoid, lacking a germ pore. No cystidia observed. **Figs 4 & 5.**

***Diagnosis.*** *Boletus kundabungkid* can be differentiated from *B. semigastroideus* Nuhn, Manfr. Binder, A.F.S. Taylor, Halling & Hibbett [replacement name for *Secotium areolatum* G.Cunn *non B. areolatus* Berk.; syn. *Notholepiota areolata* (G. Cunn.) E.Horak] by the smaller basidiomes, with a less-developed stipe, narrower spores and association with *Eucalyptus* spp. in Australia.

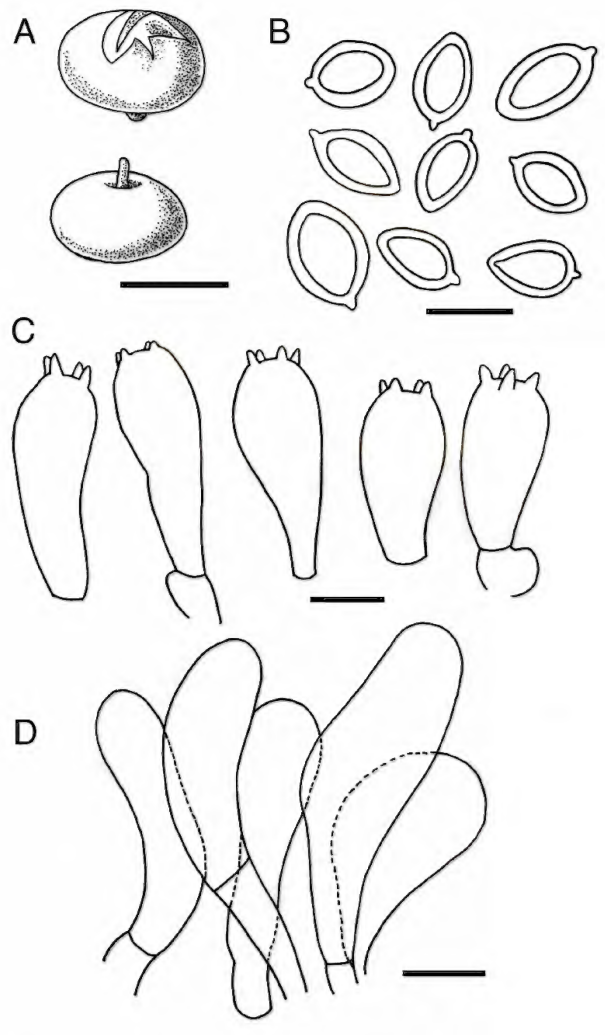


**Fig. 4.** *Boletus kundabungkid* illustration. **A** Basidiomata; **B** spores; **C** basidia; **D** pileipellis terminal elements. Scale bars: A = 10 mm, B–D = 10 µm. — Line drawing by K. Syme.

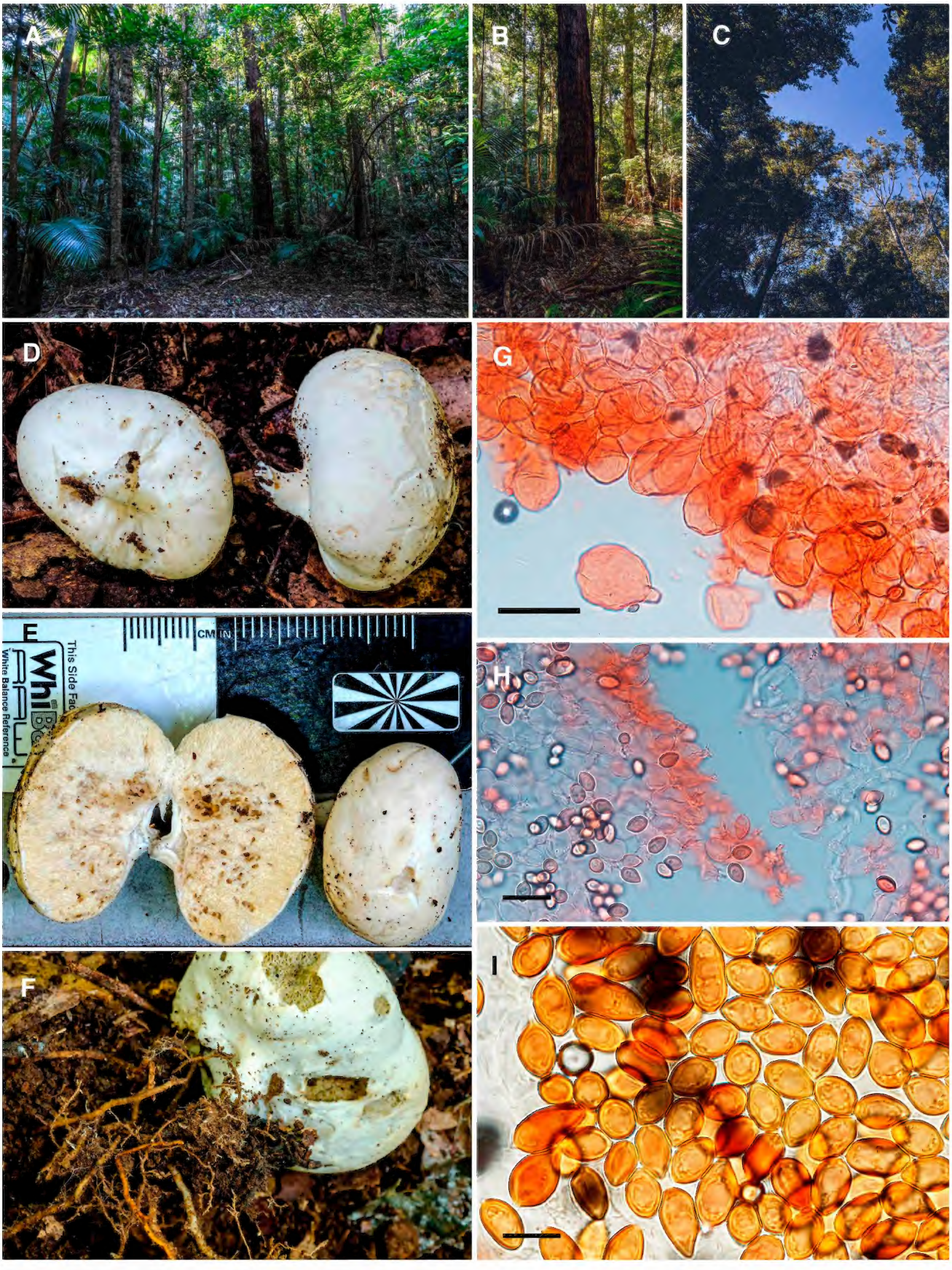


**Fig. 5.** *Boletus kundabungkid*. **A–C** Habitat images from type locality, showing dense bush and tall canopy; **D–F** basidiomata fresh; **G** palisade pileipellis chains of inflated terminal elements; **H** hymenophoral trama showing spores, basidia, basidioles and tramal elements; **I** spores. Scale bars: G = 40 µm, H = 20 µm, I = 10 µm. — D–F *I. Dodd s.n.* (MEL2417154, holotype). Photos: I. Dodd (A–F), T. Lebel (G–I).

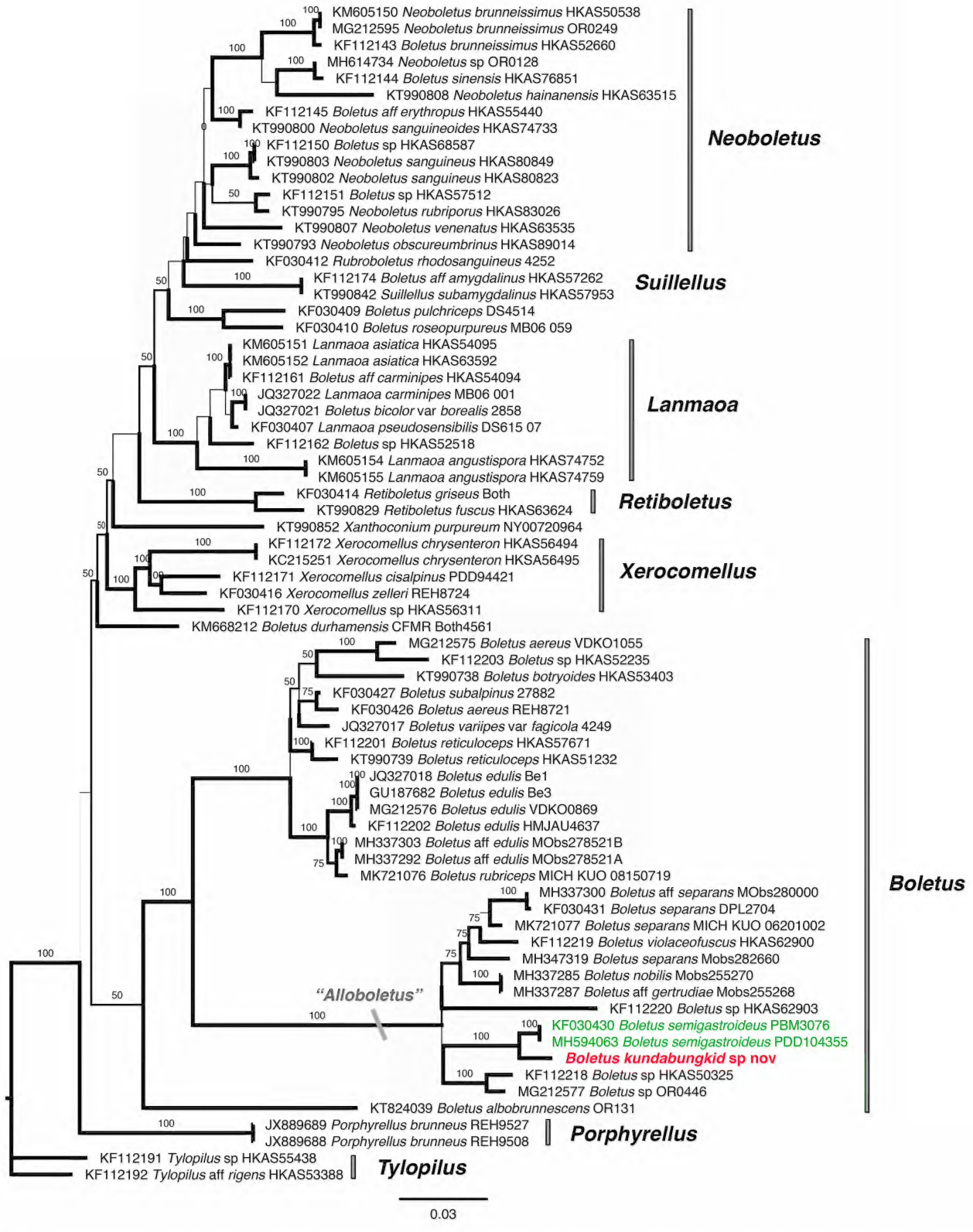


**Fig. 6.** Bayesian majority rule phylogram of partial TEF1-α sequences for *Boletus kundabungkid* and related taxa. Scale bar shows substitutions per site. Bayesian posterior probabilities (bpp) are shown at the nodes. Thickened lines indicate PP support ≥ 0.95.

***Ecology & distribution.*** In small groups, hypogeous, in mixed rainforest in association with *Eucalyptus* spp.; Known only from type locality.

***Notes.*** In the field this collection was initially thought to be a specimen of *Lepiota geogenia* T.Lebel & Vellinga, due to the small, pale cream basidiomes, and chambered pale hymenophore with somewhat cartilaginous texture. However, in maturity the hymenophore of *L. geogenia* becomes pale olive green, and microscopically the larger (14.5–) 19 × 6–7 µm, more ellipsoid, dextrinoid spores are distinctive (Lebel & Vellinga 2013). Both *L. geogenia*

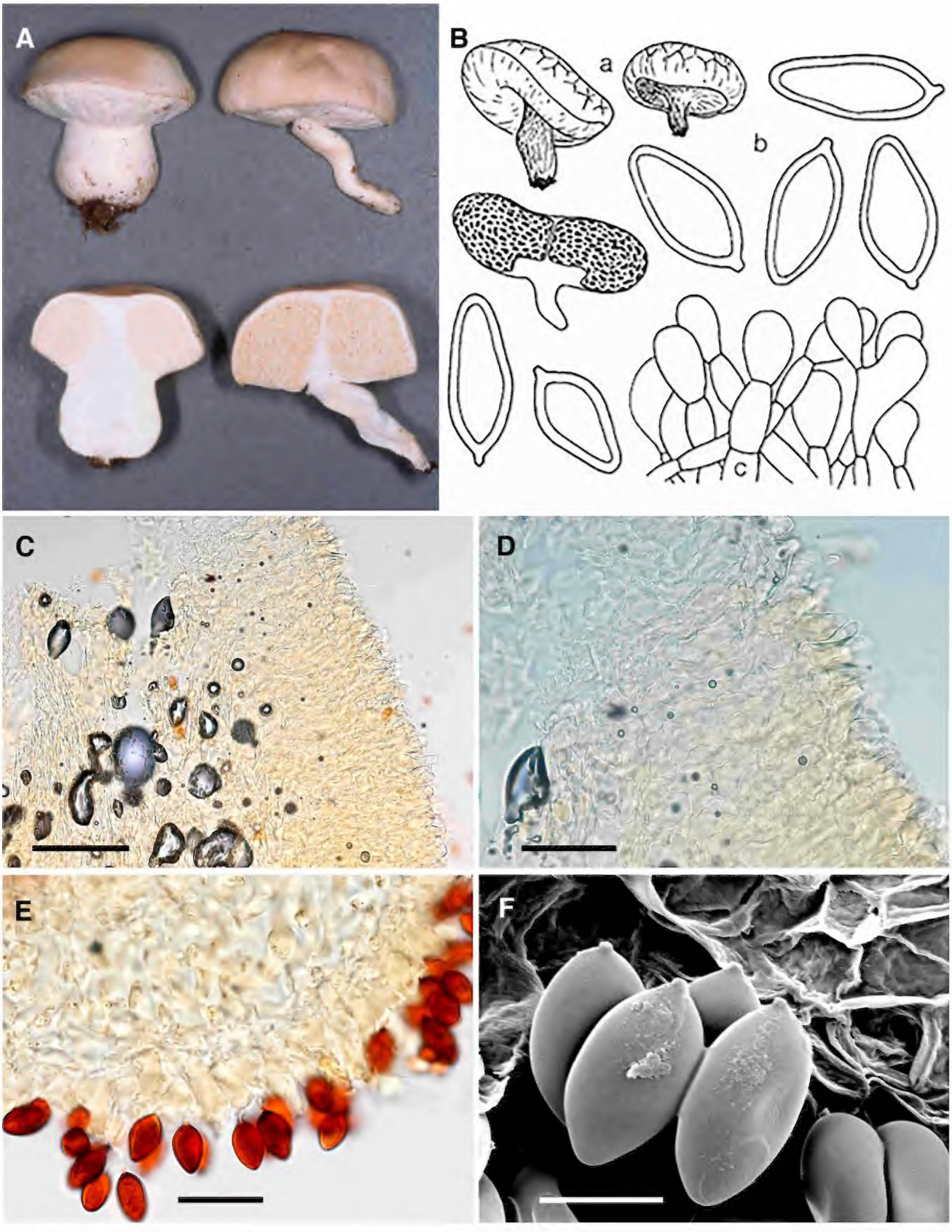


**Fig. 7.** *Boletus semigastroideus* (New Zealand). **A** Basidiomata; **B** illustration (as *Notholepiota areolata*), reproduced from Horak (1971); **C** pileus structure; **D** pileipellis; **E** hymenium, basidia, spores; **F** SEM of spores. Scale bars: C = 100 µm, D = 50 µm, E = 20 µm, F = 10 µm. — A *R.E. Beever* (PDD65276), C–E *R.E. Beever* (PDD68925); F *R.E. Beever* (PDD65277). Photos: T. Lebel (C–F).

and *Boletus kundabungkid* have been found in mixed lowland rainforest habitats in association with *Syzygium* spp. and *Eucalyptus* spp., in north eastern Australia.

*Boletus kundabungkid* is the first record from Australia of a sequestrate species in the almost entirely epigeous porcini clade (*B. edulis* Bull. and related species); it occurs in the "*Alloboletus*" subclade, comprising *B. violaceofuscus*, *B. separans*, and relatives (Dentinger *et al.* 2010; Nuhn *et al.* 2013; Fig. 6). *Boletus kundabungkid* is sister to the sequestrate *B. semigastroideus* from New Zealand based on independent analyses of 4 genes, and macro- and micro-characters. BLAST comparison of our *B. kundabungkid* ITS sequence matched publicly available ITS sequences of *B. semigastroideus* (GenBank: KP191796, JX258840) at 93.13%. *Boletus kundabungkid* typically has smaller basidiomes than *B. semigastroideus*, with a less-developed stipe, slightly wider spores and the pileipellis has chains of globose to broadly clavate terminal elements forming an epithelium-like layer. In *B. semigastroideus* the pileipellis is more palisadal to hymeniform (Fig. 7; Horak 1971, as *Notholepiota*). In Australia, *B. kundabungkid* is found in association with *Eucalyptus*, whereas in New Zealand *B. semigastroideus* is associated with *Leptospermum*.

***Etymology.*** Specific epithet is a noun in apposition that refers to Ian Dodd the 'Kundabung Kid' who has made extensive collections and photos of intriguing fungi in an understudied area.

**Russulaceae** Lotsy.

*Russula* Pers. is an important ectomycorrhizal genus with high species diversity worldwide. The infrageneric classification of *Russula* is going through considerable change in light of recent multi-locus phylogenies with eight well-supported subgenera proposed (Looney *et al.* 2016; Bazzicalupo *et al.* 2017; Buyck *et al.* 2018, 2020). In Australia research on epigeal agaricoid *Russula* species remains limited, with only 24 species described in the last 20 years (Cleland 1976; Miller & Hilton 1986; Grgurinovic 1997). On the other hand, sequestrate *Russula* have been more extensively studied, with over 50 species described (Beaton *et al.* 1984; Bougher 1997; Elliott & Trappe 2019; Lebel & Trappe 2000; Lebel 2002a, b, 2003a, b; Trappe & Claridge 2003; Lebel & Tonkin 2007). However, placement of taxa in a phylogenetically stable section and subgeneric backbone of *Russula* as a whole remains to be completed.

Keys to Australian species of sequestrate *Russula* are available in Lebel & Castellano (2002), Lebel (2003a, b) and Lebel & Tonkin (2007). We place the two new species described below into a key to species that updates the key presented in Lebel (2003b: as *Gymnomyces*) with species names according to Lebel (2017). For further details of species not differentiated in the key below, see Lebel (2003b).

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### Updated key to Australian species of sequestrate *Russula*

Note that couplet numbers retain the numbering of the key in Lebel (2003b).

**1.** Spore ornamentation isolated, spinose

**2.** Basidia with mostly 2 sterigmata

**3.** Spore ornamentation 2–3 µm tall, many spines distinctly forked . . . . . ***Russula furcatispina***

**3:** Spore ornamentation 0.5–2 µm tall, of straight spines or of irregular rods, warts, and knobs

**3a.** Hymenophore off-white to ivory initially, blackening in age, odour sharp of acetylene, pileipellis a trichoderm, basidia clavate to cylindrical, 24–39 × 6–12 µm. Currently known from New Zealand. . . . . ***Russula spinispora*** (= *Gymnomyces fuscus*)

**3b:** Hymenophore initially off-white, becoming pale yellow, then eventually tan brown to brown, odour slightly fishy, pileipellis a patchy turf of hyphal tips and short cystidia, basidia broadly clavate to obovate, 22–28 × 12–16 (–20) µm. Currently known from New South Wales . . . . . 4. ***Russula crassibasidiata***

**2:** Basidia with (2, 3) 4 sterigmata . . . . . ***Russula paneeroides*** (= *Gymnomyces pallidus*), ***R. eburnea*** & ***R. leucocarpa***

**1:** Spore ornamentation reticulate, partially reticulate or elements connected in distinct lines or ridges

**6.** Spores ovate to ellipsoid (spore width 4–6 µm); ornamentation < 0.3 µm high, slowly amyloid (+ 10 min) . . . . . ***Russula longispora***

**6:** Spores globose or subglobose (spore width 7–14 µm); ornamentation mostly > 0.5 µm high, immediately amyloid

**7.** Spore ornamentation 2–4 µm high, of branched, irregular ridges or isolated robust spines connected in a partial to complete reticulum, margins more strongly amyloid than sides . . . . . ***Russula aurantirosea*** (= *Gymnomyces clelandii*), ***R. osphranticarpa*** (= *G. redolens*), ***R. leonardii*** (= *G. rodwayi*), ***R. costatispora***, ***R. korystospora*** (= *G. cristatus*) & ***R. pterosperma***

**7:** Spore ornamentation generally < 2 µm tall, of spines, rods or warts connected in a partial to complete reticulum

**13.** Spore ornamentation 1–2 µm high; basidiomata white with brown patches . . . . . ***Russula glarea***

**13:** Spore ornamentation < 0.8 µm tall; basidiomata white to pale yellow or brown, with red to orange patches

**14.** Hymenial cystidia absent; peridiopellis undifferentiated from context; basidia 35–50 µm long, cylindrical to narrowly clavate . . . . . ***Russula wirrabarensis***

**14:** Hymenial cystidia present; pileipellis a turf or trichodermium, which may be agglutinated and appressed in patches; basidia generally shorter, not as distinctively cylindrical

**15.** Peridiopellis appearing as an ixocutis or in patches as an agglutinated turf of hyphal tips . . . . . ***Russula parvisaxoides*** & ***R. eildonensis***

**15:** Pileipellis a dense trichodermium or turf of cystidia

**17.** Peridium pale yellow with orange to brick-red or brown streaks and patches or overall pale yellow; subhymenium of irregular elements 5–13 µm diam. . . . ***Russula westresi***

**17:** Pileus white to pale yellow in youth, becoming brownish white with some brown to ochre mottling; subhymenium of isodiametric elements, 6–21 µm diam

**17a.** Hymenophore cream-coloured to pale yellow, locules small, fine, odour mild, slightly spicy and fishy, taste slightly acrid, pileipellis a trichoderm with 2 or 3 tiers of cells, 6–25 × 7–12 µm, terminating in a golden turf of hyphal tips and cystidia. Known only from central New South Wales . . 5. ***Russula danksiae***

**17b:** Hymenophore white to pale yellowish-orange, locules large, open, elongate, odour faintly of chlorine, taste mild, pileipellis a turf of hyphal tips and cystidia. Known only from southern WA. . . . . ***Russula boranupensis***

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### 4. *Russula crassibasidiata* T.Lebel, Davoodian & Castellano, *sp. nov.*

**Holotypus:** Australia, New South Wales: Narrabri, Pilliga Nature Reserve, 18 July 2007, *M. Danks, J.M. Trappe, T. Lebel, K. Vernes KV631* (MEL2364422).

**Registration identifier: IF557866.**

*Basidiomata* sequestrate, subglobose to elongate, with a plane apex and incurved margins, 15–32 mm long and wide, 14–37 mm tall, hymenophore exposed for a few mm in some basidiomes. *Pileus* surface dry, smooth to minutely fibrillose, cracking into irregular patches in larger basidiomes, pale tan-yellow to pale orange-brown becoming darker ochre brown to brown with age. *Hymenophore* loculate, locules minutely labyrinthine, initially off-white, becoming pale yellow, then eventually tan brown to brown (becoming darker brown where insect damaged), firm in texture. *Stipe-columella* absent, or present as a very narrow percurrent strand < 1 mm wide, and a small inserted basal pad 3–5 mm wide, 2 mm tall. *Odour* slightly fishy. *Taste* mild.

*Pileipellis* 10–25 µm wide, a patchy turf of hyphal tips, 9–22 × 2–5 (–7) µm, septate, with short, cylindrical, narrowly clavate to fusoid cystidia, 7–15 × 2–5 µm, with obtuse or sometimes acute apices, contents golden in KOH, mostly repent; overlying a broad context, 50–200 µm wide, of hyaline, loosely interwoven hyphae, 3–5 µm wide, with rare scattered sphaerocytes up to 25 µm wide. *Hymenophoral trama* 20–48 µm wide, of hyaline, interwoven to parallel hyphae, 3–6 µm wide, with abundant endocystidia, golden in KOH; *subhymenium* narrow, pseudoparenchymatous to ramose, 1–2 tiers of cells, 3–11 × 4–9 µm. *Basidia* broadly clavate to obovate, 22–28 × 12–16 (–20) µm, mostly 2-spored (rarely 3–4); sterigmata 2–5 µm long. *Hymenial cystidia* abundant, arising from within trama, clavate to cylindrical, with obtuse or sometimes capitate apices, 20–25 × 2–5 µm, with oily contents that turn golden in KOH. Spores 8.5–10 × 8–10 µm ($Q_{mean}$ = 1.03), orthotropic, globose to subglobose, irregularly amyloid ornamentation of isolated, irregular rods, warts, and knobs, 0.5–1 µm tall. **Fig. 8.**

***Diagnosis.*** Differs from other sequestrate *Russula* species in the combination of a narrow, patchy turf pileipellis, mostly 2-spored, broadly clavate to obovate basidia, and spores with mostly isolated, irregular rods, warts and knobs.

***Ecology & distribution.*** In small groups, hypogeous, in open ironbark woodlands of mixed *Eucalyptus sideroxylon*, *E. blakelyi*, *E. melliodora*, *Callitris endlicheri*, *Angophora floribunda*, and *Acacia* spp. Known only from Pilliga Nature Reserve.

***Notes.*** *Russula crassibasidiata* is known only from a small, not easily accessible, area in the Pilliga Nature Reserve in central northern New South Wales. Extensive searches in nearby areas (2007–2011) were unsuccessful (Danks 2012). This is not altogether surprising given the cryptic nature of the basidiomata and the low rainfall in the region. *Russula crassibasidiata* resembles several other sequestrate *Russula* species, including *R. pilosella* T.Lebel and *R. paneeroides* T.Lebel in the pale cream to tan basidiomes that darken in age (Lebel & Tonkin 2007; Lebel 2017).

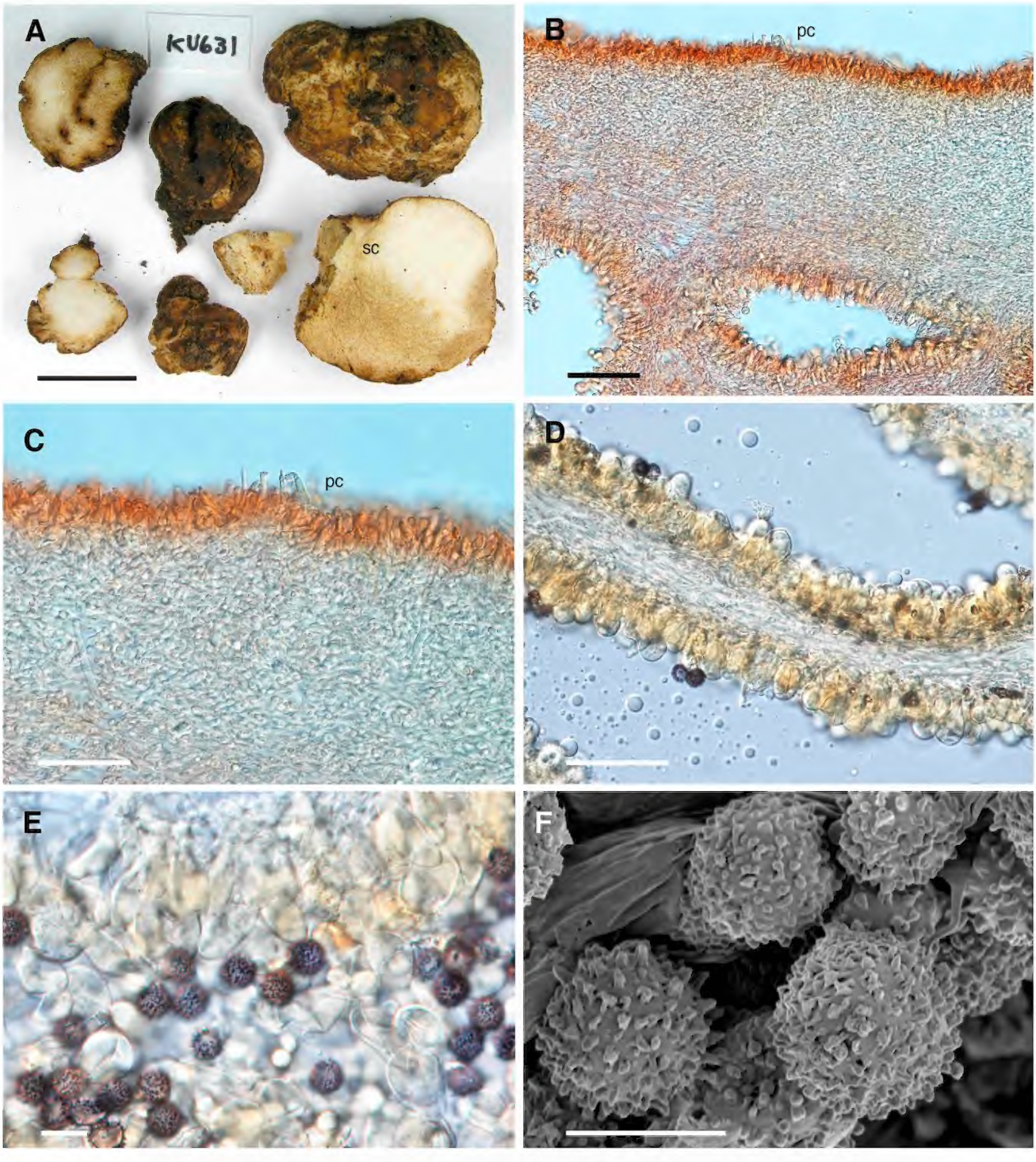


**Fig. 8.** *Russula crassibasidiata* (holotype). **A** Basidioma, sc = stipe-columella remnant; **B–C** pileipellis and context, pc = pileal cystidia; **D** hymenophoral trama showing broad basidia and cystidia; **E** spores, in Melzer's reagent; **F** SEM of spores. Scale bars: A = 10 mm, B–D = 50 µm, E–F = 10 µm. — A–F *M. Danks et al. KV631* (MEL2364422, holotype). Photo: K. Vernes (A), T. Lebel (B–F).

*Russula crassibasidiata* differs in the much-reduced stipe-columella, mostly 2-spored, broadly clavate basidia, single type of hymenophoral cystidia, and low, irregularly amyloid spore ornamentation (Fig. 8). In addition to morphological features, *R. crassibasidiata* is supported by molecular phylogenetic analysis (Fig. 9) as a distinct species, in sect. *Ingratae*, subsect. *Pectinatinae* with members of the *R. amoenolens* group (Vidal *et al.* 2019). The slightly fishy odour is consistent with the majority of other taxa in this subsection.

***Etymology.*** The specific epithet refers to the short, broadly (*crassus*) clavate basidia (adj. *basidiata*).

### *Additional material examined.*

**AUSTRALIA.** NEW SOUTH WALES. Narrabri, Pilliga Nature Reserve, 18 July 2007, *M. Danks, J.M. Trappe, T. Lebel, K. Vernes KV632* (MEL2364389); Narrabri, Pilliga Nature Reserve, 18 July 2007, *M. Danks, J.M. Trappe, T. Lebel, K. Vernes KV634* (MEL2364390).

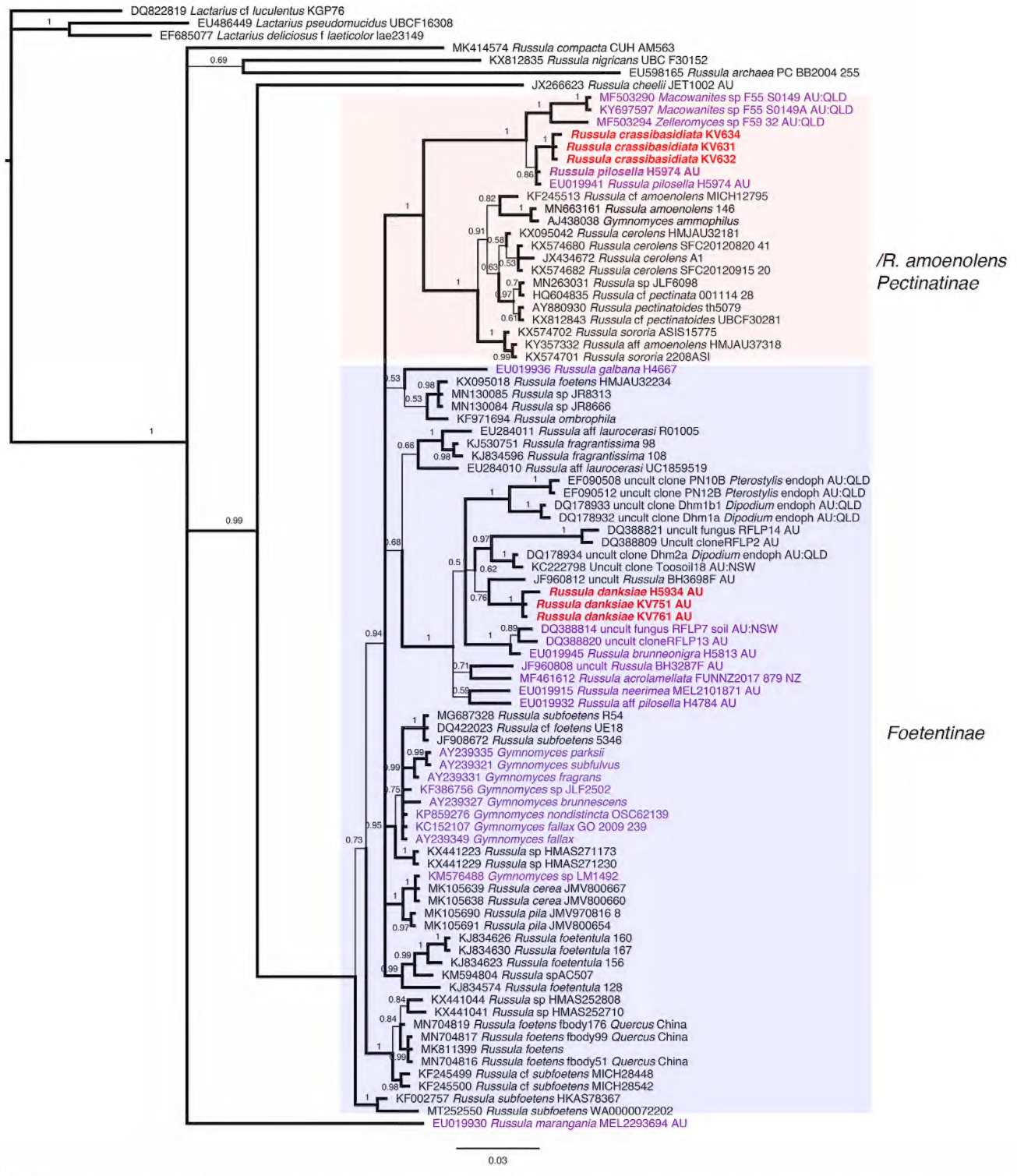
DQ822819 Lactarius cf luculentus KGP76
EU486449 Lactarius pseudomucidus UBCF16308
EF685077 Lactarius deliciosus f laeticolor lae23149
MK414574 Russula compacta CUH AM563
KX812835 Russula nigricans UBC F30152
EU598165 Russula archaea PC BB2004 255
JX266623 Russula cheelii JET1002 AU
MF503290 Macowanites sp F55 S0149 AU:QLD
KY697597 Macowanites sp F55 S0149A AU:QLD
MF503294 Zelleromyces sp F59 32 AU:QLD
Russula crassibasidiata KV634
Russula crassibasidiata KV631
Russula crassibasidiata KV632
Russula pilosella H5974 AU
EU019941 Russula pilosella H5974 AU
KF245513 Russula cf amoenolens MICH12795
MN663161 Russula amoenolens 146
AJ438038 Gymnomyces ammophilus
KX095042 Russula cerolens HMJAU32181
KX574680 Russula cerolens SFC20120820 41
JX434672 Russula cerolens A1
KX574682 Russula cerolens SFC20120915 20
MN263031 Russula sp JLF6098
HQ604835 Russula cf pectinata 001114 28
AY880930 Russula pectinatoides th5079
KX812843 Russula cf pectinatoides UBCF30281
KX574702 Russula sororia ASIS15775
KY357332 Russula aff amoenolens HMJAU37318
KX574701 Russula sororia 2208ASI
/R. amoenolens
Pectinatinae
EU019936 Russula galbana H4667
KX095018 Russula foetens HMJAU32234
MN130085 Russula sp JR8313
MN130084 Russula sp JR8666
KF971694 Russula ombrophila
EU284011 Russula aff laurocerasi R01005
KJ530751 Russula fragrantissima 98
KJ834596 Russula fragrantissima 108
EU284010 Russula aff laurocerasi UC1859519
EF090508 uncult clone PN10B Pterostylis endoph AU:QLD
EF090512 uncult clone PN12B Pterostylis endoph AU:QLD
DQ178933 uncult clone Dhm1b1 Dipodium endoph AU:QLD
DQ178932 uncult clone Dhm1a Dipodium endoph AU:QLD
DQ388821 uncult fungus RFLP14 AU
DQ388809 Uncult cloneRFLP2 AU
DQ178934 uncult clone Dhm2a Dipodium endoph AU:QLD
KC222798 Uncult clone Toosoil18 AU:NSW
JF960812 uncult Russula BH3698F AU
Russula danksiae H5934 AU
Russula danksiae KV751 AU
Russula danksiae KV761 AU
DQ388814 uncult fungus RFLP7 soil AU:NSW
DQ388820 uncult cloneRFLP13 AU
EU019945 Russula brunneonigra H5813 AU
JF960808 uncult Russula BH3287F AU
MF461612 Russula acrolamellata FUNNZ2017 879 NZ
EU019915 Russula neerimea MEL2101871 AU
EU019932 Russula aff pilosella H4784 AU
Foetentinae
MG687328 Russula subfoetens R54
DQ422023 Russula cf foetens UE18
JF908672 Russula subfoetens 5346
AY239335 Gymnomyces parksii
AY239321 Gymnomyces subfulvus
AY239331 Gymnomyces fragrans
KF386756 Gymnomyces sp JLF2502
AY239327 Gymnomyces brunnescens
KP859276 Gymnomyces nondistincta OSC62139
KC152107 Gymnomyces fallax GO 2009 239
AY239349 Gymnomyces fallax
KX441223 Russula sp HMAS271173
KX441229 Russula sp HMAS271230
KM576488 Gymnomyces sp LM1492
MK105639 Russula cerea JMV800667
MK105638 Russula cerea JMV800660
MK105690 Russula pila JMV970816 8
MK105691 Russula pila JMV800654
KJ834626 Russula foetentula 160
KJ834630 Russula foetentula 167
KJ834623 Russula foetentula 156
KM594804 Russula spAC507
KJ834574 Russula foetentula 128
KX441044 Russula sp HMAS252808
KX441041 Russula sp HMAS252710
MN704819 Russula foetens fbody176 Quercus China
MN704817 Russula foetens fbody99 Quercus China
MK811399 Russula foetens
MN704816 Russula foetens fbody51 Quercus China
KF245499 Russula cf subfoetens MICH28448
KF245500 Russula cf subfoetens MICH28542
KF002757 Russula subfoetens HKAS78367
MT252550 Russula subfoetens WA0000072202
EU019930 Russula marangania MEL2293694 AU
0.03

**Fig. 9.** Bayesian majority rule phylogram of concatenated LSU and ITS data for a selection of closely related taxa in *Russula* subgenus *Heterophyllidiae*, section *Ingratae*. Bayesian posterior probabilities (bpp) are shown at the nodes. Thickened lines indicate PP support ≥ 0.95. Taxon labels in red indicate the new taxa *R. crassibasidiata* and *R. danksiae*. Labels in purple indicate other sequestrate species.

### 5. *Russula danksiae* T.Lebel & Castellano, *sp. nov.*

**Holotypus:** Australia, New South Wales: Guy Fawkes National Park, horse exclusion experiment partial exclusion plot 1, 5 Aug. 2009, *K. Vernes, M. Danks & T. Lebel KV761* (MEL2363640).

**Registration identifier: IF557867.**

*Basidiomata* sequestrate, subglobose to ellipsoidal, to 12–20 mm long and wide, 15–20 mm tall. *Pileus* surface smooth, cream-coloured to dull yellow with brown spots; texture cottony to finely tomentose. *Hymenophore* loculate; locules small, cream-coloured to pale yellow. *Stipe-columella* absent or present as a narrow percurrent strand, to 0.5 mm wide, pale

brownish yellow. *Odour* mild, slightly spicy and fishy. *Taste* slightly acrid.

*Pileipellis* 25–48 µm wide, a trichoderm with 2 or 3 tiers of cells, 6–25 × 7–12 µm, terminating in a turf of hyphal tips and cystidia, 18–40 × 3–9 µm, apices obtuse, capitate or fusoid, with some golden yellow pigment on outer surface of cells; overlying a context, 75–210 µm wide, of compact, short, septate, interwoven, parallel hyphae, 3–7 µm wide, and inflated hyphae up to 16 µm wide, with scattered clavate endocystidia, 17–20 × 5–6 µm. *Hymenophoral trama* 10–25 µm wide, of gelatinised hyphae, 2.0–4.5 µm wide; *subhymenium* 10–25 µm wide, well-developed, of 2–4 layers of hyaline, parenchymatous cells, 6–16 µm wide. *Basidia* clavate, (18–) 25–30 × (7–) 8–10 µm, mostly 4-spored; sterigmata up to 4–5 µm long. *Hymenial cystidia* rare, cylindrical to narrowly clavate, 16–30 × 4–6 µm, with granular contents. *Spores* subglobose to ellipsoidal, 8.5–10.0 × 7–8 µm ($Q_{mean}$ = 1.37); ornamentation a partial to almost complete reticulum with scattered isolated warts, 0.3–0.5 µm tall, irregular in height. **Fig. 10.**

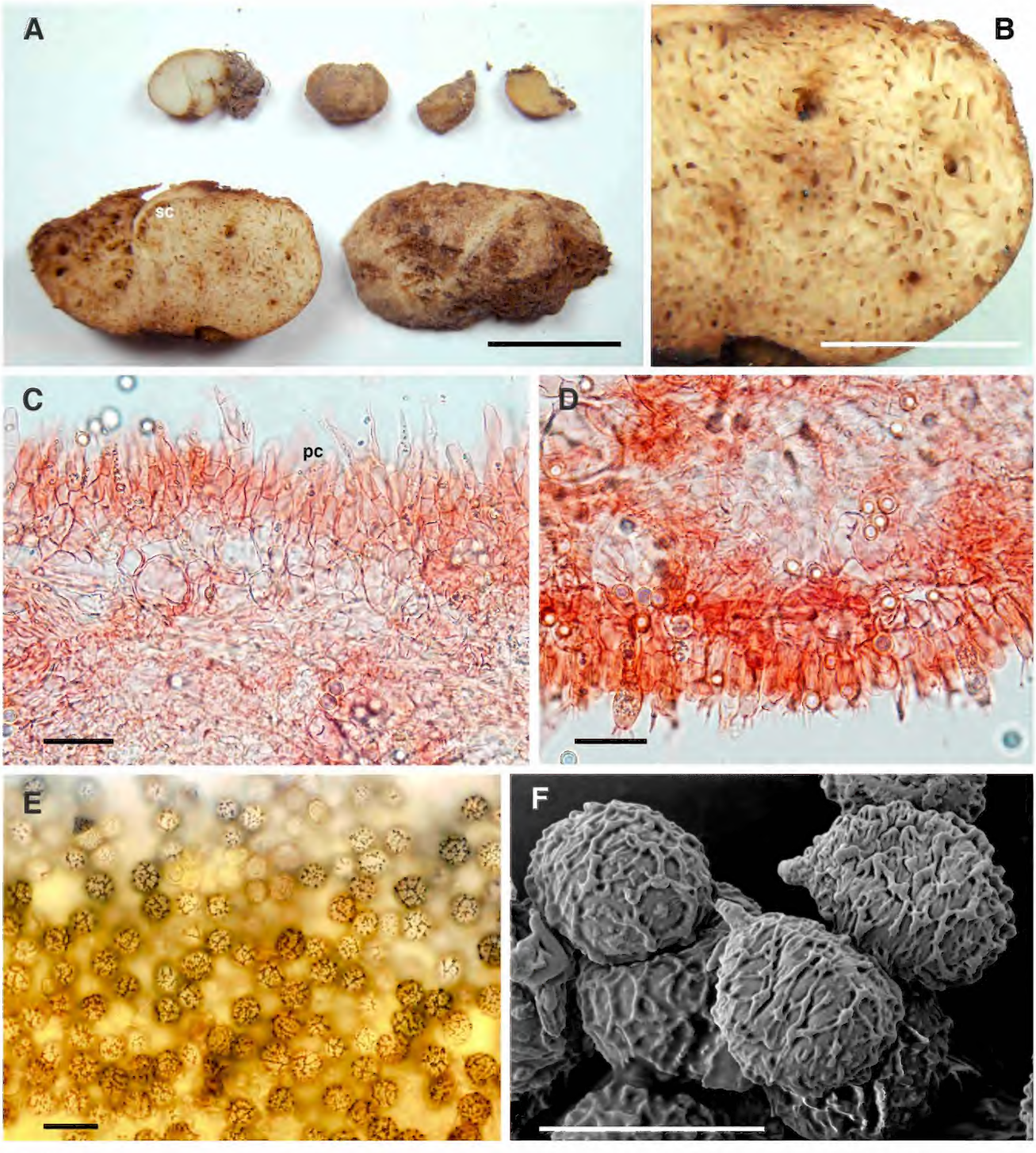


**Fig. 10.** *Russula danksiae* (holotype). **A** Basidiomata, sc = stipe-columella remnant; **B** closeup of loculate hymenophore; **C** pileipellis and context, pc = pileal cystidia; **D** hymenophoral trama showing basidia and cystidia; **E** spores, in Melzer's reagent; **F** SEM of spores. Scale bars: A = 10 mm, B = 5 mm, C–E = 20 µm, F = 10 µm. — A–F *K. Vernes et al. KV761* (MEL2363640). Photos: K. Vernes (A, B), T. Lebel (C–F).

***Diagnosis.*** Differs from other sequestrate *Russula* species in the combination of large hymenophoral locules, a golden trichodermial pileipellis, and low, fine, distinctly reticulate spore ornamentation.

***Ecology & distribution.*** Hypogeous in grassy eucalypt woodland in northeastern New South Wales.

***Notes.*** *Russula danksiae* resembles *R. boranupensis* (T.Lebel) T.Lebel in the pale basidiomata that become mottled with brown and ochre, but differs in the quite large, empty hymenophoral locules, a trichodermial rather than cystidial turf pellis, and the spore ornamentation being distinctly more reticulate with fewer isolated elements (Lebel 2003b, 2017; Fig. 10). In the field this species was initially thought to be related to *Lactarius* rather than *Russula*, due to the texture of the basidiomes and hymenophore with larger, more open locules. It was thought that the basidiomata had dried out (no latex or moisture visible). However, analysis of ITS sequences (Fig. 9) places *Russula danksiae* in a strongly supported clade of Australasian *Russula* species, with *R. neerimea* Grgur., *R. acrolamellata* McNabb and *R. brunneonigra* T.Lebel (Lebel & Tonkin 2007), *R. aff. pilosella* (H4784), and several environmental sequences. The environmental sequences include soil sequences and sequences from orchid mycorrhizas. *Russula danksiae* is a member of sect. *Ingratae*, subsect. *Foetentinae*.

***Etymology.*** Specific epithet refers to Melissa Danks, an excellent naturalist, ecologist, and collector of native truffle species.

***Additional material examined.***

**AUSTRALIA.** NEW SOUTH WALES. Guy Fawkes National Park, horse exclusion experiment control plot 1, 5 Aug. 2009, *K. Vernes, M. Danks & T. Lebel KV751* (MEL2363642); Gibraltar National Park, Gibraltar Gorge, 2 May 1992, *J.M. Trappe H5934* (OSC).

### Psathyrellaceae Vilgalys, Moncalvo & Redhead

Redhead *et al.* (2001) introduced the family Psathyrellaceae to accommodate the genera *Psathyrella* (Fr.) Quél. and *Lacrymaria* Pat., together with related species in the polyphyletic genus *Coprinus sensu lato*, which were transferred to the genera *Coprinellus* P. Karst., *Coprinopsis* P.Karst. or *Parasola* Redhead, Vilgalys & Hopple. Kirk *et al.* (2008) broadened the concept of the family to include 12 genera. More recently, Wachter & Melzer (2020), proposed a new generic system for Psathyrellaceae, recognising an additional six new genera. *Coprinopsis* is a large genus with 20 subgenera, that contains around 200 species (Kirk *et al.* 2008; Wachter & Melzer 2020). They are saprotrophic and occur on soil, wood, vegetable refuse, dung or burnt ground, and produce agaricoid, rather fragile basidiomes which are often short-lived and/or deliquescent, with a blackish spore deposit. This is the first record in the genus *Coprinopsis* of a sequestrate basidiome form, or a species with pale spores.

### 6. *Coprinopsis pulchricaerulea* T.Lebel, Padamsee & T.W.May, *sp. nov.*

**Holotypus:** Australia, New South Wales: Booyong, 565 Houghlahans Creek Rd, 19 Oct. 2009, *S. Axford s.n.* (MEL2363909)

**Registration identifier: MB841411.**

*Le Ratia atrovirens* R.Heim, *Rev. Mycol.* 33: 143 (1968), *nom. inval.* — *Le Ratia atrovirens* R.Heim, *Rev. Mycol.* 33: 212 (1968), *nom. inval.* MB333316. — *Leratiomyces atrovirens* (R.Heim) Bresinsky & Manfr. Binder, *Z. Mykol.* 64(1): 80 (1998), *nom. inval.* MB446995.

*Basidiomata* 8–28 × 6–22 mm, spherical at first then ellipsoid to ovoid or sometimes turbinate, apex convex, margin remaining in-rolled though not necessarily attached to stipe, not completely covering hymenophore in most basidiomes, pale blue to bright sky blue or sometimes watery greenish blue, becoming dark greyish green when dry or in very old basidiomes, covered in tiny, fine, white warts/granular glistening spheres which wash off or erode as basidiome ages, otherwise appearing smooth, non-deliquescent. *Hymenophore* lamellate to sublamellate, with some labyrinthine fusions between lamellae, white to pale cream becoming pale tan, moderately packed. *Stipe* 5–20 mm long, 3–7 mm diam., variable, central, cylindrical, slightly bulbous at base tapering slightly to apex, dry, silky in age, white; context solid or hollow in some basidiomes, white or occasionally with pink tinge. *Partial veil* present, white, fibrillose to floccose remnants apparent on stipes of immature specimens, towards base. *Odour* strongly mushroom-like. *Taste* not distinctive. Basidiomata fragile, easily disintegrate on handling.

*Pileipellis* a thin cutis of hyaline hyphae, 4–12 µm diam., overlying inflated cells bunching into upright hyaline clusters to form small warts with elongated apices, 5–11 cells deep, composed of spherical, subglobose to oblong inflated elements, (18–) 25–48 (–72) × (16–) 32–45 (–60) µm, becoming interwoven with some cylindrical hyphae, 3–7 µm diam., in small parallel bundles, with occasional inflated elements, 10–16 µm diam., towards the base of the 'warts'. *Pileus context* a broad layer 500–1100 µm thick, composed of interwoven hyphae 3–7 µm diam., with occasional inflated elements 8–19 µm diam. All hyphae in pileipellis and pileus context with scattered, irregular coating of pigment on outer surface; appears golden brownish in KOH and water in sections of dried material. *Hymenophoral trama* narrow, composed of loosely interwoven to occasionally parallel, hyaline, septate hyphae 4–8 µm diam.; *subhymenium* parenchymatous, 5–12 × 5–10 µm, with scattered hyphal elements. *Basidia* 18–32 × 6–12 µm, clavate to cylindrical, with slightly thickened wall, hyaline, mostly 4-spored, some 2-spored, squashed in between highly inflated basidioles, 26–58 × 18–52 µm,

globose to obclavate, hyaline, thin-walled. *Hymenial cystidia* none observed. *Spores* (17–) 19–23 × 10–12.5 µm, mean = 19.07 ± 1.48 × 10.74 ± 1.42 µm, Q = 1.82–3.43, $Q_{mean}$ = 2.19, ellipsoid to elongate, some misshapen, germ pore absent but some with pale lens at apex (otherwise no interruption), hyaline to very pale brown in KOH, inamyloid, nondextrinoid, smooth, thick-walled with a small apiculus. Clamps present at basidiole base. **Figs 11 & 12.**

***Diagnosis.*** Differs from other *Coprinopsis* species in the blue coloration of the basidiomata, the sequestrate basidiome form, pale hymenophoral tissue and spores at all stages of maturity.

**Fig. 11.** *Coprinopsis pulchricaerulea*. **A–D** Examples of fresh basidiomata: **A–C** New South Wales; **D** New Caledonia. **E** Habitat (New South Wales). Scale bars: C = 5 mm, D = 10 mm. — Photos: S. Axford (A–C, E), T. Lebel (D).

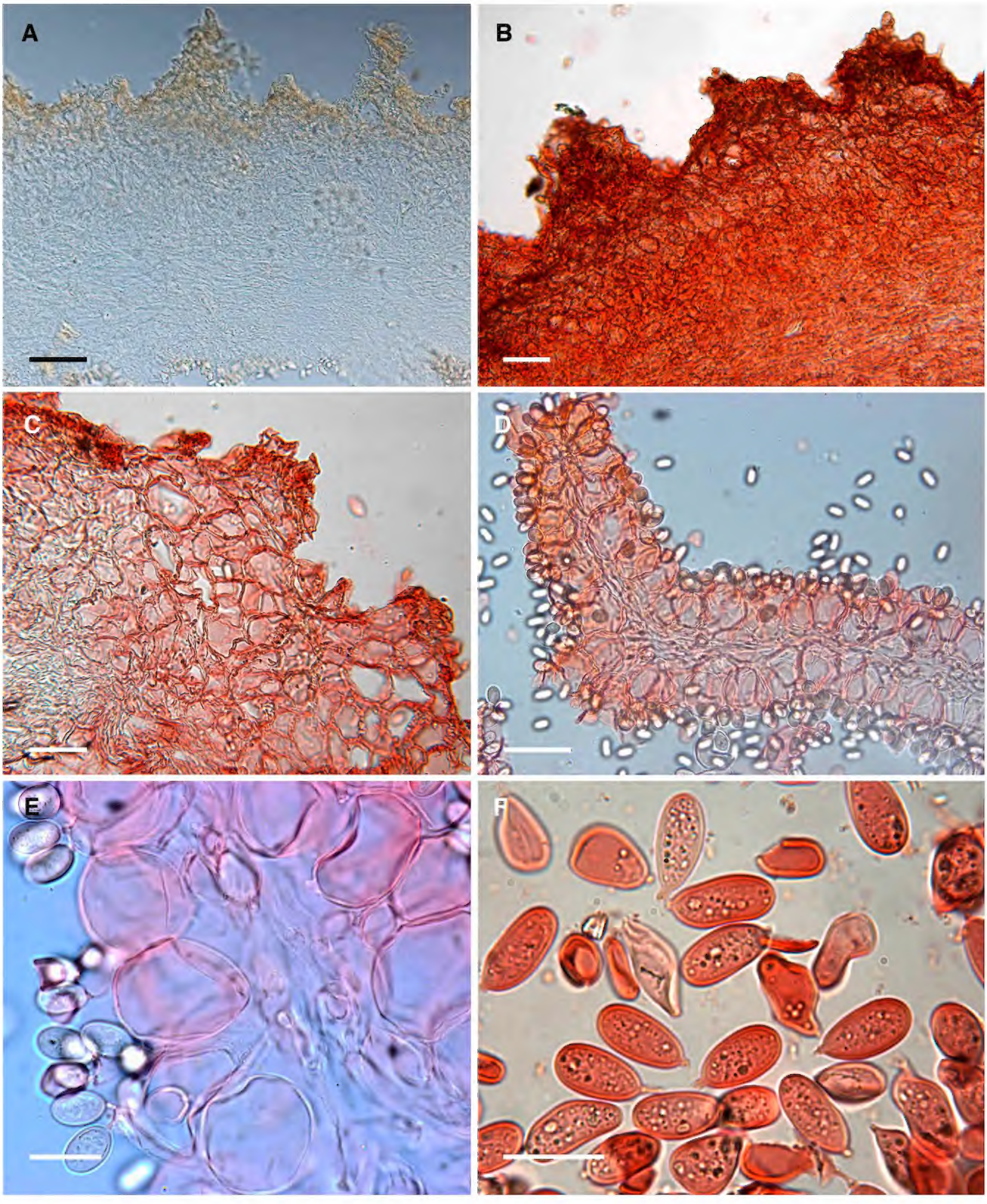


**Fig. 12.** *Coprinopsis pulchricaerulea* (paratype). **A–B** Pileipellis and context; **C** closeup of pileipellis showing granular structure; **D** hymenophoral trama showing basidia and inflated basidioles; **E** basidia, inflated basidioles and hymenophoral trama; **F** spores. Scale bars: A–D = 50 µm, E–F = 20 µm. — A–F *S. Axford B001* (MEL2363910). Photos: T. Lebel.

***Ecology & distribution.*** Growing in small groups or solitary on soil and leaf litter and decaying branchlets in dense, wet forest or rainforest in northern New South Wales and New Caledonia; on Lord Howe Island on rocky path in wet dense forest, verging on rainforest, near paddock.

***Notes.*** Redhead & McNeill (2008) discuss in detail the nomenclature of the name "*Le Ratia*" Pat. (invalid due to the space in the name), the illegitimate name *Le-Ratia* Pat. ex. Sacc. & Trotter (*non Leratia* Broth. & Paris) and efforts to introduce *Leratiomyces*, culminating in the valid publication of *Leratiomyces* Bresinsky &

Manfr. Binder ex Bridge, Spooner, Beever & D.-C. Park by Bridge *et al.* (2008). The type of *Leratiomyces* is *Leratiomyces similis* (Pat. ex Sacc. & Trotter) Bresinsky & Manfr. Binder ex Redhead & McNeill, a dull red, sequestrate taxon from New Caledonia; a second red sequestrate species from New Zealand is also accepted in the genus, *Leratiomyces erythrocephalus* (Tul. & C.Tul.) Beever & D.-C. Park (Bridge *et al.* 2008; Redhead & McNeill 2008). Two blue to green sequestrate species originally placed in "*Le Ratia*" were assigned to *Leratiomyces* by Bresinsky & Binder (1998) but excluded from the genus by Bridge *et al.* (2008) on the basis of sequence data, with *Leratiomyces atrovirens* suggested to belong in the /psathyrella clade and *L. smaragdinus* suggested to belong in the /agrocybe clade. Our phylogenetic analysis places recent collections from Australia and New Caledonia that match the original description of "*Le Ratia atrovirens*" within the genus *Coprinopsis* (Fig. 13).

According to Redhead & McNeill (2008) all three existing names with '*atrovirens*' as an epithet (see above in synonymy) are invalid. The material of "*Le Ratia atrovirens*" examined by Heim (1968) is apparently in poor condition [not seen by us: New Caledonia, in silva Thi, in foliis putridis, 21 June 1967, leg. *J.M. Veillon s.n.* (PC)]. Longstanding confusion exists between the two blue-green sequestrate species in New Caledonia originally named "*Le Ratia atrovirens*" and "*Le Ratia smaragdina*", with some considering basidiomes with the brown hymenophore of the latter as the mature stage of the former. This is not the case, basidiomes with a brown hymenophore belong to a different genus (see *Agrocybe smaragdina* below). This confusion persists among citizen science observations in iNaturalist and other sites. It is also possible that cryptic taxa remain to be uncovered. As a result, we have chosen to name this taxon as a new species, with a new epithet, and typify with a more recent Australian collection, which has sufficient material, images and molecular data.

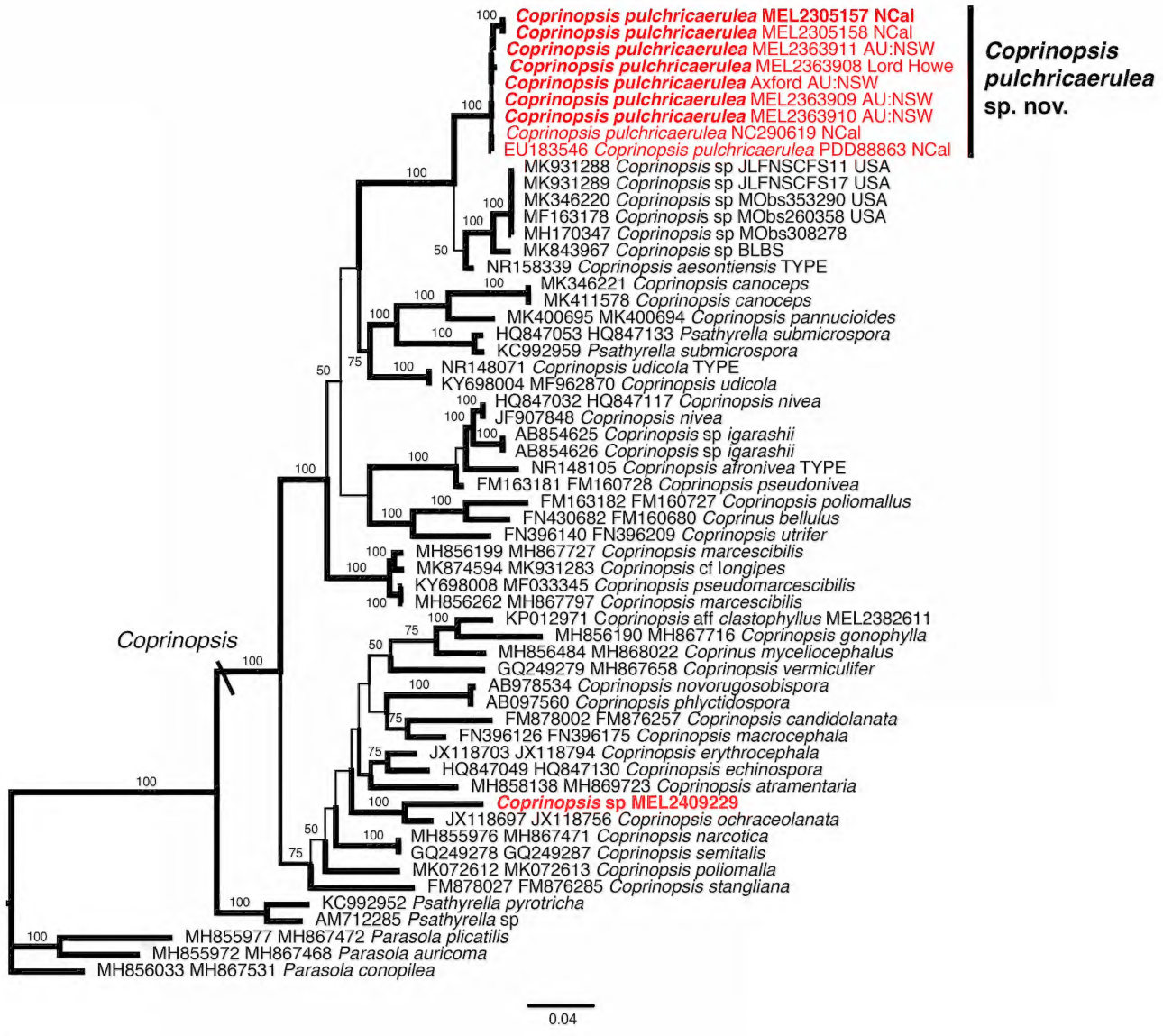


**Fig. 13.** Maximum Likelihood phylogram of concatenated ITS and LSU data representing a selection of sections within *Coprinopsis*, with *Parasola conopilea* as the outgroup. ML bootstrap support are shown at the nodes; thickened lines indicate ML support ≥ 80%. Taxon labels in red indicate *Coprinopsis pulchricaerulea*, and a novel agaricoid species (MEL2409229).

The tiny, fine, white warts/granular glistening spheres observed on the basidiome surface are not single cell structures. Rather they are chains of hyaline, inflated cells that form elongated pyramidal warts that allow light to pass through.

New Caledonian specimens of *Coprinopsis pulchricaerulea* had barely any white glistening structures visible, except in crevices and near the margin of the pileus of basidiomes. In two of these collections (MEL2305157, MEL2305158) the spores are slightly smaller and less ellipsoid-elongate: 17–20 × 10–12 µm, mean = 18.85 ± 0.74 × 11.40 ± 0.66 µm, Q = 1.58–1.90, $Q_{mean}$ = 1.67. However, the differences are slight and could be due to maturity or age of material. Otherwise, microscopically these collections match other material in all details. In addition, sequences are very similar to those of collections from Australia, and the two New Caledonian collections do not form a distinct or well-supported clade. Therefore, one taxon is accepted, occurring in Australia and New Caledonia. Investigation of population genetic structure across this disjunct distribution will be of interest as there are few examples of sequestrate taxa with a distribution separated by large stretches of ocean.

Our DNA analysis (Fig. 13) places *Coprinopsis pulchricaerulea* close to *C. aesontiensis* A.Melzer, Ferisin & Dovana (Melzer *et al.* 2016), and an undescribed *Coprinopsis* sp. (California, USA; ITS: MK346220, MH170347; https://mushroomobserver.org/353290; https://mushroomobserver.org/308278) in what used to be section *Canoceps* (Wachter & Melzer 2020). *Coprinopsis pulchricaerulea* resembles *C. aesontiensis* and the *Coprinopsis* sp. (USA) in the pileus texture (but is blue not grey or white), absence of pleurocystidia, and growth on wood. The pileus of *C. pulchricaerulea* generally remains attached to the stipe, rarely exposing the hymenophore, unlike the other two taxa which form typical agaricoid basidiomata.

It is intriguing that the transition from dark to light spore colouration has occurred multiple times in the Agaricaceae, i.e., in *Coniolepiota* Vellinga and *Eriocybe* Vellinga (Vellinga *et al.* 2011), and in several sequestrate Australian *Agaricus* species (Lebel & Syme 2012). *Coprinopsis pulchricaerulea* occurs in subtropical rain forests with an often closed canopy and the spore mass is not exposed, so melanisation for protection of the spores may not be necessary. The bright basidiome colours of some sequestrate fungi from New Zealand have been postulated to be related to mycophagy by birds and reptiles rather than mammals (Beever & Lebel 2014); perhaps this is also the case for this brightly coloured wet forest inhabitant?

Thanks to the concerted efforts of local field naturalists, particularly S. Axford, this rare fungus has been found in three small remnants of lowland subtropical rainforest early settlers called 'the Big Scrub' in northern New South Wales. These small pockets are within a 25 km radius of Booyong Nature Reserve. Similarly, in both New Caledonia and on Lord Howe Island, all collections or iNaturalist records have been made within a restricted geographic area of 5–20 km$^2$.

***Etymology.*** The specific epithet is from Latin *pulcher* (beautiful) and *caeruleus* (blue) referring to the striking colour of the basidiomes.

***Additional material examined.***

**AUSTRALIA.** NEW SOUTH WALES. Booyong, Tara Ridge, Dec. 2009, *S. Axford B001* (MEL2363910); Nightcap National Park, Big Scrub loop tk, Dec. 2009, *S. Axford B007* (MEL2363911); Lord Howe Island, c. 100 m inland of W end of Old Settlement Beach, July 2009, *J. Derkenne s.n.* (MEL2363908).

**NEW CALEDONIA.** Koghis, Cascade Track branch to giant Kauri in vicinity of kauri, 4 Dec. 2003, *P.R. Johnston & R.E. Beever 2202* (PDD88863); Parc Riviere Bleue, Le Geant Kaori walk trail, within first 100 m of trail, 29 Nov. 2000, *T. Lebel 820* (MEL2305157); Parc Riviere Bleue, Le Geant Kaori walk trail, within first 100 m of trail, 29 Nov. 2000, *T. Lebel 821* (MEL2305158).

## **Strophariaceae** Singer & A.H.Sm.

Strophariaceae includes both decomposers growing on various kinds of organic matter, such as dung, soil and plant litter, as well as ectomycorrhizal species (Borovička *et al.* 2011; Cho *et al.* 2016; Frings *et al.* 2020; Lee *et al.* 2020). Species in the genus *Agrocybe* Fayod are decomposers, with a rusty brown, tobacco brown or dark brown spore print, typically the basidiospores have a broad germ pore, a hymeniform pileipellis composed of inflated cells and conspicuous cheilocystidia (Singer 1986; Largent & Baroni 1988; Niveiro *et al.* 2020). Vizzini *et al.* (2014) transferred several species, with larger basidiomes, a membranous annulus, and a rudimentary or absent germ pore to the genus *Cyclocybe* (V.Brig.) Vizzini. Sequestrate forms are not common, but have evolved more than once in the genus (Malysheva *et al.* 2019).

### 7. *Agrocybe smaragdina* (Pat. ex Sacc. & Trotter) T.Lebel, K.Hosaka, T.W.May & Padamsee, ***comb. nov.***

**Registration identifier: MB841231.**

*Le-Ratia smaragdina* Pat. ex Sacc. & Trotter, *Syll. Fung.* 21: 468 (1912). MB532576. — **Holotype:** New Caledonia: Ad truncus vetustos montis Dzumac, *Le Rat 108* (FH, Herb. Patouillard).

*Le Ratia smaragdina* Pat., *Bull. Soc. Mycol. France* 25: 133 (1909), *nom. inval.* (Art. 35.1). MB178862. — *Leratiomyces smaragdinus* (Pat.) Bresinsky & Manfr. Binder, *Z. Mykol.* 64(1): 80 (1998), *nom. inval.* (Art. 35.1). MB446998.

*Pileus* 8–14 mm tall, 6–30 mm diam., subglobose, apex convex to planoconvex, margin remaining incurved, bright turquoise green fresh, drying yellowish, somewhat crevassed, but otherwise smooth, dry. *Hymenophore* labyrinthine loculate, locules somewhat irregular shaped,

**Fig. 14.** *Agrocybe smaragdina*. **A** General habitat, Riviere Bleue P.P., New Caledonia; **B** dense mixed canopy forest, Riviere Bleue P.P., New Caledonia; **C–E** fresh basidiomes showing brown hymenophore, remnant stipe and partial veil (pv); **F** hymeniderm pileipellis and pileal context; **G** closeup of hymeniderm pileipellis; **I–J** spores. Scale bars: C–E = 10 mm, F–G = 50 µm, I–J = 20 µm. — Photos: K. Hosaka (A, C–E), T. Lebel (B, F–J).

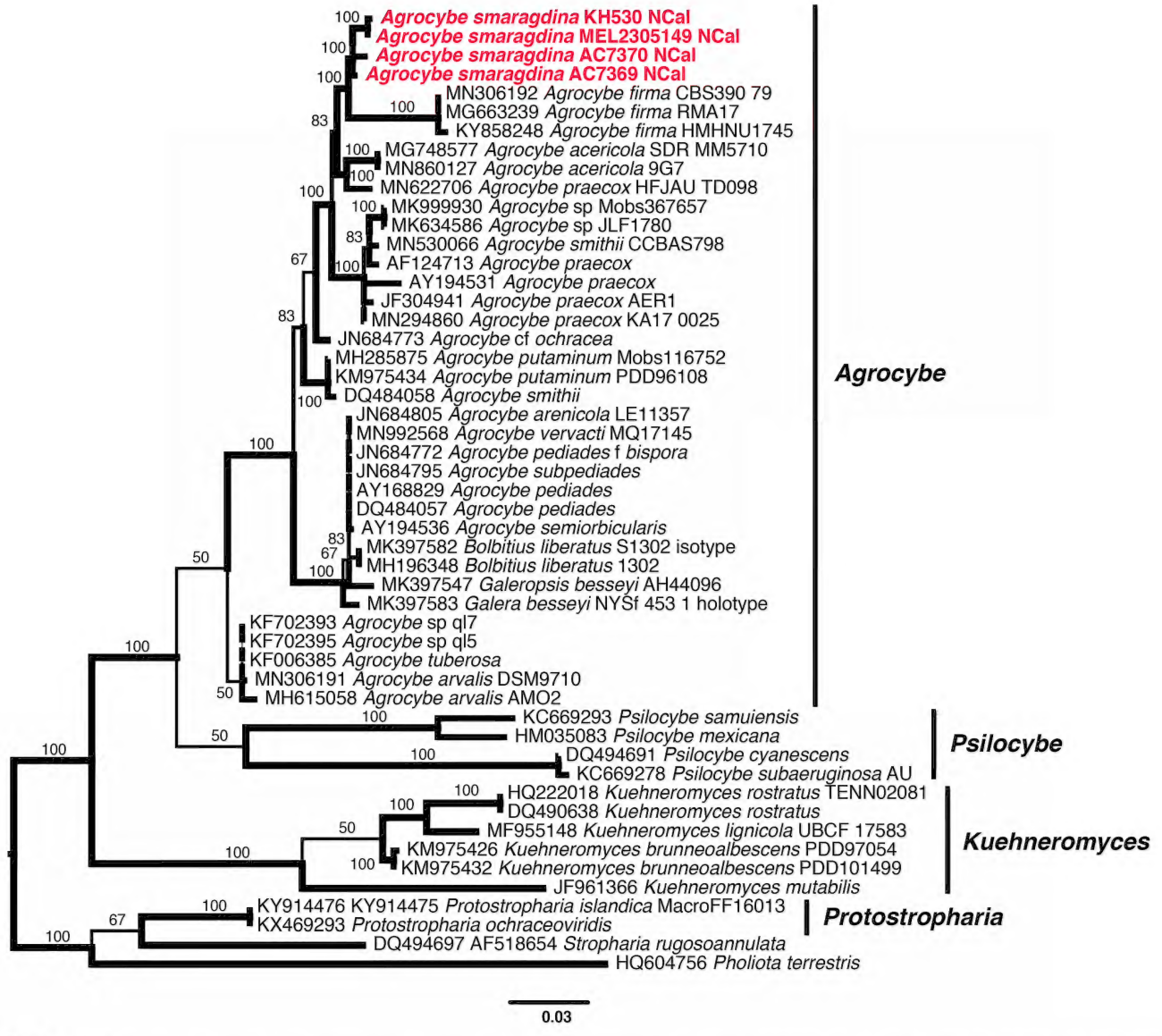


**Fig. 15.** Maximum Likelihood phylogram of ITS data including representative *Agrocybe* species, other Strophariaceae and *Pholiota terrestris* as outgroup. ML bootstrap support shown at the nodes; thickened lines indicate ML support ≥ 75%. Taxon labels in red indicate *Agrocybe smaragdina*.

empty, ochre brown. *Stipe-columella* 5–10 × 1–2.5 mm, percurrent, short, central with slight basal bulb, smooth, white with greenish tinge. *Partial veil* present, white, silky, remaining attached to pileus margin and stipe, enclosing hymenophore at base. *Basal rhizomorphs* white, abundant. *Odour* not distinctive. *Taste* mild.

*Pileipellis* thin, 45–60 µm thick, hymeniform, terminal cells clavate to cylindrical, 24–36 (–42) × 9–14 (–15) µm, hyaline, merging into a narrow layer of parenchymatous cells, 2–3 cells deep, 5–14 × 5–12 µm; context 50–80 µm wide, of interwoven inflated hyphae 5–12 µm diam., becoming more parallel towards hymenium. *Hymenophoral trama* 35–50 µm wide, of parallel, hyaline hyphae 4–7 µm diam., and scattered inflated elements to 14 µm diam. *Basidia* 18–29 × 6–12 µm, clavate, hyaline, 4-spored; basidioles similar size and shape. *Hymenial cystidia* none observed. *Spores* (12–) 14–15.5 (–17) × (6.5–) 7–8 µm, mean = 15.50 ± 0.94 × 7.18 ± 0.61, Q = 1.88–2.33, $Q_{mean}$ = 2.17, broadly ellipsoid to ellipsoid, pale yellow to yellow-brown, smooth, thick-walled, with small germ pore, non-dextrinoid. **Fig. 14.**

***Ecology & distribution.*** Growing in small groups or solitary, on soil and leaf litter and decaying branchlets in dense, wet forest. New Caledonia.

***Notes.*** Redhead & McNeill (2008) point out that the designation "*Le Ratia smaragdina*" as introduced by Patouillard (1909) is invalid as is "*Leratiomyces smaragdinus* (Pat.) Bresinsky et Manfr. Binder", but *Le-Ratia smaragdina* Pat ex Sacc. & Trotter is a valid name that can serve as the basionym for the combination into *Agrocybe*. Although Redhead & McNeill (2008) use the masculine spelling "*smaragdinus*" for *Le-Ratia smaragdina*, *Le-Ratia* Pat. ex Sacc. & Trotter is feminine, following Patouillard (1907, 1909) who introduced "*Le Ratia similis*" and "*Le Ratia smaragdina*" and Saccardo

& Trotter (1912) who validated the generic name with species *Le-Ratia similis* and *L. smaragdina* with those spellings.

In addition to "*Le Ratia atrovirens*" (formally named above as *Coprinopsis pulchricaerulea*) and *Agrocybe smaragdina*, several dark-spored sequestrate taxa with blue to blue-green basidiomata have been variously placed in the genera *Secotium* Kunze, *Clavogaster* Henn. and *Weraroa* Singer. *Secotium novaezelandiae* G.Cunn. was described from New Zealand, and later placed in *Weraroa*, of which it is the type species. It is now recognised as a *Psilocybe* species (of which *Weraroa* is a synonym) under the replacement name *Psilocybe weraroa* Borov., Obornik & Noordel. *Clavogaster novozelandicus* Henn. was described from New Zealand as the type of *Clavogaster*, and later synonymised with *C. virescens* (Massee) J.A.Cooper (based on *Secotium virescens* Massee from New Zealand).

*Agrocybe smaragdina* differs from other blue-green sequestrate species from New Caledonia and New Zealand in both macro- and micro-morphology. *Coprinopsis pulchricaerulea* has larger basidiomata, a well-developed stipe, blue or blue-green colour, a pale mature hymenophore, and slightly larger spores that lack a distinct germ pore. Meléndez-Howell (1967: as "*Le Ratia smaragdina*") presents a transmission electron micrograph of the spore of *A. smaragdina* showing a distinct germ pore, with the ectospore markedly thinner at the truncate spore apex, and a germ pore is also visible under the light microscope.

The New Zealand species, *Psilocybe weraroa* (Bridge *et al.* 2008) and *Clavogaster virescens* have larger basidiomata (2–5 cm tall) that are irregularly roundish, elliptical or with a pyramidal/pointy apex, pale brown or pale blue when young, becoming pale blue grey to sky blue, with a dark brown spore mass, and cartilaginous stipe up to 4 cm long.

Phylogenetically, *A. smaragdina* is part of a strongly-supported clade (ML 100%) that includes *A. praecox* (Pers.) Fayod, *A. acericola* (Peck) Singer, *A. firma* (Peck) Singer and *A. smithii* Watling & H.E.Bigelow (Fig. 15). *Agrocybe firma* appears to be the closest agaricoid taxon (ML 100%). It appears that some names in this genus have been broadly applied based on morphological characters as some species are present in multiple places in the phylogenetic tree. Therefore, further analyses with more genes will be required to clarify species boundaries and relationships (Niverio *et al.* 2020). Nevertheless, the placement of *A. smaragdina* within the genus *Agrocybe* is confirmed from the phylogenetic analysis. Several species with sequestrate basidiome forms have recently been transferred from the genus *Galeropsis* Velen. or *Bolbitius* Fr. to *Agrocybe* (Malysheva *et al.* 2019). They all tend to have quite different appearing basidiomes, with small, partly enclosed conical to subconical pilei, partially anastamosed lamellae or loculate hymenophore, long slender stipe, ochre-brown spore mass, and a hymeniderm pileipellis. Most of the species are rare and occur in sandy, grass rich habitats rather than tropical rainforest as does *Agrocybe smaragdina*. These taxa, *A. liberata* (Kalchbr.) E.F.Malysheva and *A. besseyi* (Peck) E.F.Malysheva, G.Moreno & M.Villarreal, are more closely related to *A. pediades* (Fr.) Fayod, *A. vervacti* (Fr.) Singer and *A. arenicola* (Berk.) Singer, based on ITS data (Fig. 15; note names in phylogeny are those used in GenBank). It appears that the sequestrate basidiome form has evolved more than once in different clades within the genus, as is commonly observed for the origin of the sequestrate form in a number of genera in various orders, including Agaricales and Russulales (Sheedy *et al.* 2016).

### *Additional material examined.*

**NEW CALEDONIA.** Northern Province, Mt Panie Massif nr Heinghen, 26 Nov. 2000, *T. Lebel 809* (MEL2305149); 1964, *B. Huguenin NC64227* (K(M)177208); Riviere Bleue Provincial Park, along Riviere Bleue, nr Pont Germain, 26

### Key to blue-green sequestrate species of Psathyrellaceae and Strophariaceae in Australasia

**1.** Basidiomes blue or blue-green, with a pale hymenophore at maturity, spores lacking a distinct germ pore . . . . . 6. ***Coprinopsis pulchricaerulea***

**1:** Basidiomes pale brown, pale blue, blue-grey, blue-green, bright turquoise green, with a dark brown hymenophore, spores with a narrow or broad germ pore

**2.** Basidiomes 6–30 mm wide, 8–14 mm tall, bright turquoise green when fresh, stipe narrow < 3 mm diam.; occurs in New Caledonia . . . . . 7. ***Agrocybe smaragdina***

**2:** Basidiomes typically larger, 10–30 mm wide, 20–50 mm tall, pale brown, pale blue, blue-grey when fresh, stipe > 3 mm diam.; occurs in New Zealand

**3.** Basidiomes with a reddish brown to rusty brown hymenophore and typically greyish blue or sky blue pellis, forming an elongated pouch often narrow and tapered at apex; spores with broad germ pore . . . . . ***Clavogaster virescens***

**3:** Basidiomes with a chocolate- or sepia-brown hymenophore and typically greyish blue becoming pallid-green pellis, with obtuse to slightly pointed apex ; spores with narrow barely visible germ pore . . . . . ***Psilocybe weraroa***

Apr. 2004, *K. Hosaka KH-NC04-024* (TNS-F-34123; OSC122556); Reserve Speciale Botanique de Foret Nord, c. 5 km from Pic du Grand Kaori toward Goro, 30 Apr. 2004, *K. Hosaka KH-NC04-059* (TNS-F-33732; OSC122560); Reserve Speciale Botanique de Foret Nord, c. 5 km from Pic du Grand Kaori toward Goro, 30 Apr. 2004, *K. Hosaka KH-NC04-057* (TNS-F-34727; OSC122558); Reserve Speciale Botanique du Pic du Grand Kaori, Grand Lac, 2 May 2004, *K. Hosaka KH-NC04-081* (TNS-F-34162; OSC122561).

### Hysterangiaceae E.Fisch.

We follow the current treatment of families in Hysterangiales according to Hosaka *et al.* (2006) and Davoodian *et al.* (2021). Based on DNA (ITS, atp6, TEF1-α) and morphological data, Davoodian *et al.* (2021) uncovered 26 provisional genera, established 2 new suborders, made 2 combinations and confirmed generic boundaries for 11 published taxa. The northern hemisphere genus name *Hysterangium* has been broadly applied worldwide to at least 9 clades/provisional genera, based on a few morphological characters (green or brown, gelatinised gleba, rubbery texture, spores with or without a utricle). The circumscription of *Hysterangium* and these 'hysterangioid' genera is in process; the new genus proposed here, *Statesia*, is one of these.

### ***Statesia*** Castellano, T.Lebel, Davoodian & K.Hosaka, ***gen. nov.***

**Typus:** *Statesia cazaresii* Castellano, T.Lebel, Davoodian & K.Hosaka.

**Registration identifier: IF557961.**

*Basidiomata* hypogeous, sequestrate, subglobose, surface glabrous or tomentose, white, often staining brownish to reddish. *Peridium* single to double-layered, textura intricata, textura porrecta or textura angularis, hyaline to brownish. *Gleba* loculate, locules empty, partially filled or filled, reddish to brownish or olive. *Rhizomorphs* often numerous, adherent across the surface. *Columella* dendroid. *Basidia* 2-spored. *Basidiospores* ellipsoid, broadly ellipsoid, fusoid to broadly fusiform, surface somewhat smooth to verrucose, base pedicellate, utricle distinct or amorphous.

***Notes.*** A phylogenetic analysis based on a combined dataset of ATP6 and TEF1-α DNA sequence data (Fig. 17) shows *Statesia* clusters with *Aroramyces* Castellano & Verbeken and two other unnamed genera designated *gen. prov.* 14 (Australian and New Zealand taxa) and *gen. prov.* 16 (western North America; *gen. prov.* numbers as per Davoodian *et al.* 2021; *Statesia* was listed as *gen. prov.* 15 in this reference). *Statesia* differs from these genera in having only 2-spored basidia and somewhat smooth to verrucose spores without spines embedded within a uniformly inflated utricle. Therefore, *Statesia* is described as a new genus based on phylogenetic and morphological comparison. As currently understood, *Statesia* is a northern hemisphere genus from temperate zones, typically occurring in association with species of *Quercus* or occasionally *Fagus*.

***Etymology.*** In honor of Jack States, former Professor at Northern Arizona State University, mycologist and truffle enthusiast.

### 8. ***Statesia cazaresii*** Castellano, T.Lebel, Davoodian & K.Hosaka, ***sp. nov.***

**Holotypus:** Mexico: Guanajuato State, near Guanajuato, Hwy 110, Dolores Hidalgo-Guanajuato, at km post 83, elevation 7600 ft. [under *Quercus* sp. and *Arctostaphylos* sp.], 23 Sept. 1996, *J.M. Trappe 19263* (OSC159158).

**Registration identifier: IF557962.**

*Basidiomata* sequestrate, subglobose, up to 16 mm wide, surface glabrous when fresh, finely tomentose when dried with scattered individual or clusters of dark hyphae, white with some brown-tinged areas and slowly staining brown when exposed when fresh, mottled off-white and pale brown when dried. *Gleba* loculate, gelatinized, brown to dark cinnamon brown when mature, pale gray in youth, locules small, partially empty. *Rhizomorphs* scattered, appressed and emergent on sides and base, concolorous with peridium or pale brown. *Columella* dendroid, arising from base, brown gray to opaque, 1–2 mm wide at base. *Odour* medicinal, penetrating. *Taste* mild.

### Key to species of *Statesia*

**1.** Peridium a single layer, 300–400 µm thick, of compact interwoven hyphae, spores appearing smooth, 13.9–16.2 × 6.4–7.0 µm, $Q_{mean}$ = 2.2 . . . . . 11. ***Statesia zelleri***

**1:** Peridium with 1 or 2 layers, spores longer and thinner on average

**2.** Spores distinctly verrucose beneath utricle, 16.8–18.6 x 5.8–7.0 µm, mean 18.1 x 6.2 µm, $Q_{mean}$ = 2.8 . . . . . 10. ***Statesia pompholyx***

**2:** Spores appearing smooth or distinctly verrucose beneath utricle, and shorter and $Q_{mean}$ = 2.4–2.7

**3.** Spores 15–17 (–18) x 6–7 µm, mean 16.2 x 6.6 µm, $Q_{mean}$ = 2.4; epicutis hyphae not in a gelatinised matrix and oxalate crystals absent . . . . . 8. ***Statesia cazaresii***

**3:** Spores 13.9–16.2 (–18.6) x 5.2–6.4 µm, mean 15.4 x 5.8 µm, $Q_{mean}$ = 2.7; epicutis hyphae in a gelatinized matrix and abundant oxalate crystals present . . . . . 9. ***Statesia calcarea***

*Peridium* readily separable from fresh and dried gleba, white in cross-section quickly staining pale brown when cut, 600–700 µm thick, two-layered; epicutis 100–150 µm thick, of sometimes granular, brown, branched, thin-walled, septate, interwoven hyphae, 5 µm wide, clamp connections present; subcutis 500–550 µm thick, of sometimes granular, hyaline, branched, thin-walled, septate, interwoven hyphae, irregular in width but up to 15 µm wide, clamp connections present. *Trama* 75–500 µm thick, of hyaline, gelatinized, compactly interwoven hyphae, up to 5 µm wide, clamp connections absent. *Basidia* cylindrical but slightly bent, 28–29 × 4–8 µm, hyaline, thin-walled, 2-spored; sterigmata thin-walled, hyaline, 2.3 × 2.3 µm. *Basidioles* clavate, thin-walled, hyaline, 8 × 23 µm. *Spores* fusiform, 15–17 (–18) × 6–7 µm, mean = 16.2 × 6.6 µm, Q = (2–) 2.1–2.6 (–2.8), $Q_{mean}$ = 2.4, asymmetrical, smooth, apex slightly acuminate to mostly blunt, base pedicellate, 1.2 × 2.3 µm; spore wall up to 1 µm thick, particularly at apex; utricle absent but spores agglutinated when young to form clumps; in KOH individual spores appear hyaline but olive-brown in mass, in Melzer's reagent somewhat darker but inamyloid, non-dextrinoid. **Fig. 16 A–C.**

***Diagnosis.*** *Statesia cazaresii* has a two-layered peridium, unique in the genus, and also has longer and wider spores than *S. calcarea*.

***Ecology & distribution.*** Often caespitose, hypogeous, embedded throughout a mat of white rhizomorphs and mycelium, under *Quercus* sp. and *Arctostaphylos* sp. Known only from Mexico.

***Notes.*** Based on our phylogenetic analysis (Fig. 17), *Statesia* belongs to the Hysterangiaceae and is sister to *Aroramyces*. The two-layered peridium of *Statesia cazaresii* is unique within *Statesia*. The spores are smooth but are somewhat agglutinated with one another as in *S. zelleri* (see below). *Statesia zelleri* has slightly smaller but wider spores (mean = 14.9 × 6.8 µm) to give the spores an overall squatter appearance compared to *S. cazaresii* (mean = 16.2 × 6.6 µm).

***Etymology.*** The specific epithet is in honour of Efren Cázares, mycologist and truffle enthusiast.

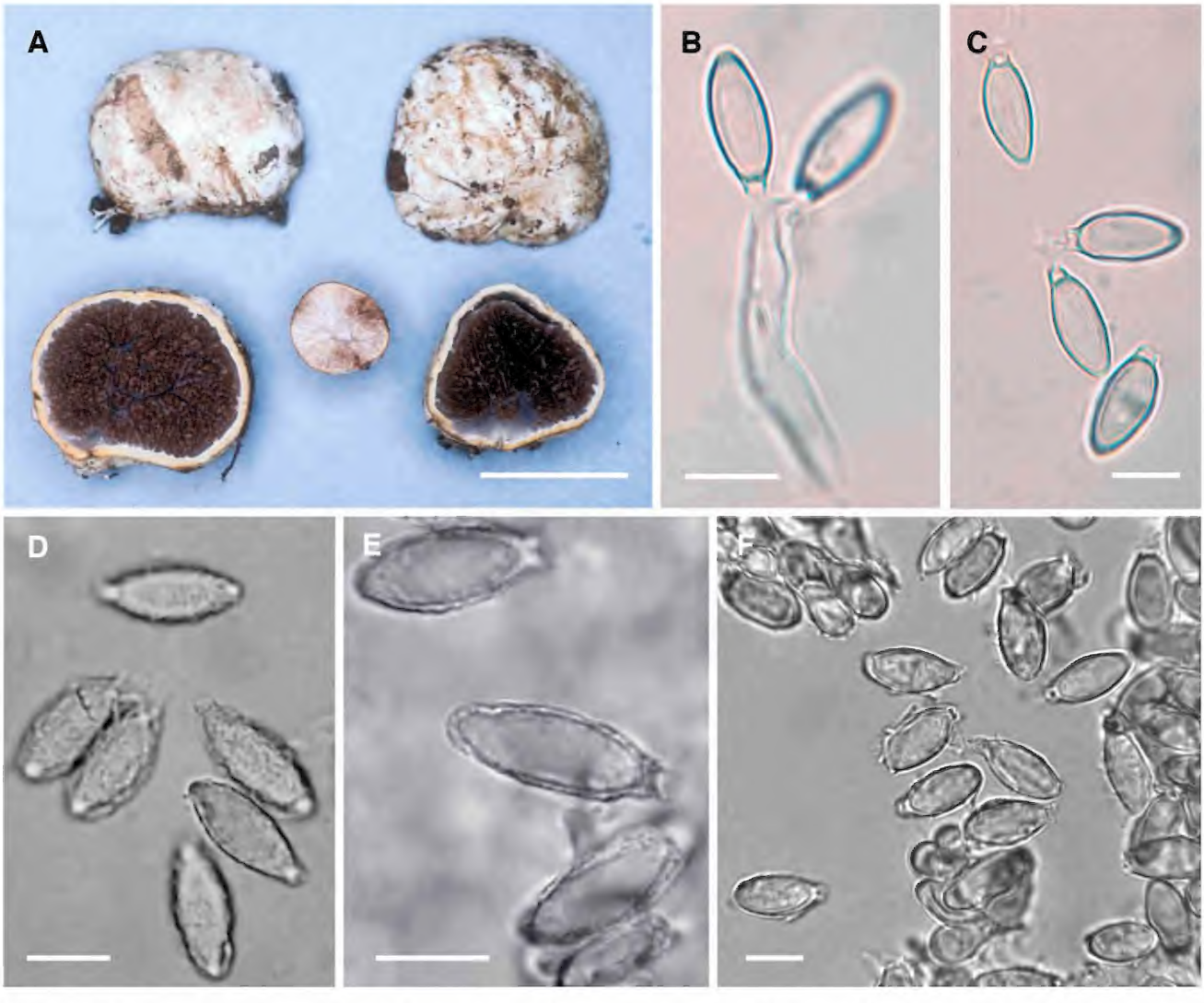


**Fig. 16. A–C** *Statesia cazaresii* (holotype): **A** Basidiomata; **B** bi-spored basidium; **C** spores. **D** *Statesia calcarea* spores. **E** *Statesia pompholyx* spores (isotype). **F** *Statesia zelleri* spores (holotype). Scale bars: A = 10 mm, B–F = 10 µm. — A–C *J.M. Trappe 19263* (OSC159158), D *A. Montecchi 2344* (OSC159163), E *L. Tulasne* (OSC159166), F *J. States AHF 602* (OSC159159).

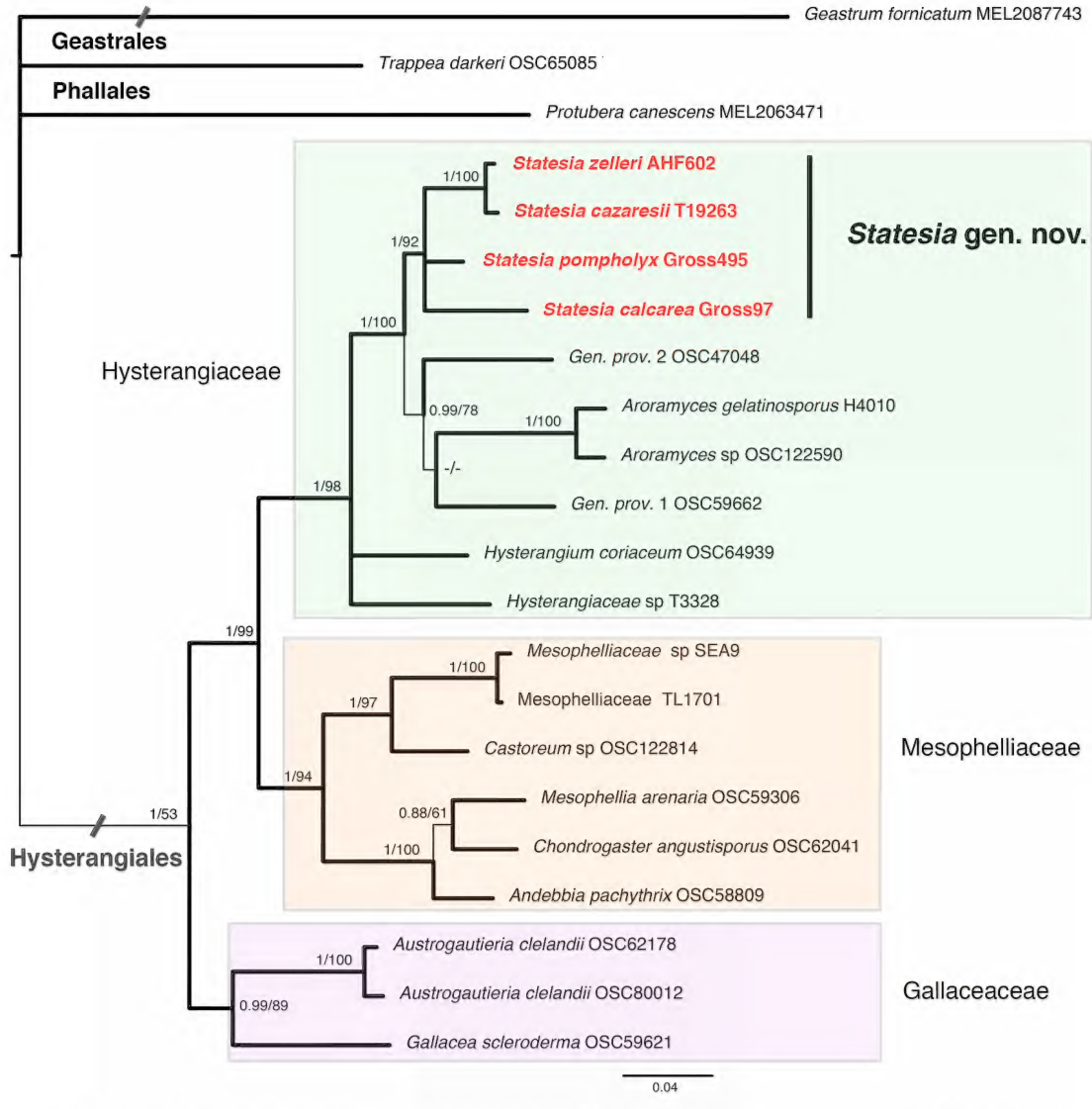


**Fig. 17.** Bayesian majority rule phylogram based on concatenated ATP6 and TEF1-α data representing *Statesia* and related taxa. Families are indicated by coloured boxes. Bayesian posterior probabilities > 0.90 and maximum likelihood bootstrap values > 50% are labeled on the nodes. Bold branches indicate support values at 0.99 (Bayesian) and 70% (maximum likelihood) or above. Scale bar shows substitutions/sites.

### 9. *Statesia calcarea* (R.Hesse) Castellano, T.Lebel, Davoodian & K.Hosaka, *comb. nov.*

**Registration identifier: IF557965.**

*Hysterangium calcareum* R.Hesse, *Hypog. Deutschl.* 1: 97 (1891). MB173046. — **Lectotype (here designated, IF555906):** Germany: Cassel, 12 July 1881, *R. Hesse* (MB).

***Description & illustration.*** See Montecchi & Sarasini (2000). **Fig. 16D.**

*Basidiomata* up to 2.5 cm, globose to subglobose, grayish white, surface floccose from covering of mycelium and mycelial strands, unchanging. *Gleba* bluish green to olive green; locules elongate, empty when young, filled at maturity. *Rhizomorphs* numerous, attached randomly on the peridial surface, commonly occurring in double strands, concolorous with peridium. *Columella* gelatinous, dendroid, stout, c. 1 µm thick, translucent when dried.

*Peridium* easily separable from gleba, 500–600 µm thick, of two layers but the layers intergrade, epicutis of brownish yellow (on extreme outer edge) to hyaline, thin-walled, disorganized to periclinal hyphae, 2.5–3.5 µm wide, either agglutinated to each other or imbedded in a gelatinized matrix, abundant oxalate crystals across layer, subcutis of hyaline, thin-walled, interwoven hyphae (*textura intricata*), 4–6 µm wide with more hyphae in profile observed, crystals present but not abundant, the two layers clearly intergrade with each other in an irregular interzone, clamp connections absent. *Trama* variable in thickness, of hyaline, compactly interwoven hyphae, 2–3 µm wide, in a gelatinized matrix, clamp connections absent. *Basidia* rehydrating poorly, 2-spored. *Spores* broadly ellipsoid or occasionally subfusiform, 13.9–16.2 (18.6) × 5.2–6.4 µm, mean = 15.4 × 5.8 µm, Q = (2.4–) 2.5–2.7 (–3.2), $Q_{mean}$ = 2.7, sometimes asymmetrical, smooth, apex blunt to occasionally papillate, base pedicellate, 1 × 2 µm wide. Spore wall 0.5–1 µm. Utricle absent, but outer spore wall irregular at times

and with mucilage when mature. Spore colour in KOH hyaline singly, gray-green in mass.

***Ecology & distribution.*** Hypogeous, usually in calcareous soil; under *Betula*, *Corylus*, *Fagus* and *Quercus* spp.; July through October. Known from Germany, Italy and Romania.

***Notes.*** Hesse (1891) lists a collection from Hessen-Nassau province (Kingdom of Prussia) in Cassel (known as Kassel since 1926) from July 1886 and also a collection from near Kirchditmold (a suburb of Kassel) in August but does not designate a type. Zeller and Dodge (1928) state that the type is probably at MB but they did not study it and based their descriptive information on a collection from Czechoslovakia, studied by Hesse. Material from MB was not available by loan to us and we appreciate the efforts of Jim Trappe to secure data for this collection from an in-person visit he made to the herbarium a few decades ago. We designate the collection in MB labeled Germany, Cassel, 12 July 1881, *R. Hesse* as lectotype.

The peridium of *Statesia calcarea* is double-layered but intergrades to appear as one; it is readily separable from the gleba, which is more characteristic of a two-layered structure. The spores of *S. calcarea* are shorter and thinner with a slightly higher $Q_{mean}$.

***Etymology.*** Probably in reference to the "calcareous" soil in which it is typically found (Hesse 1891).

***Additional material examined.***

**GERMANY.** Saar, Sitterswald, 8 Oct. 1967, *G. Gross 97* (M; OSC146868).

**ITALY.** Emilia Romagna, on eastern side of Monte Cusna, 7 Sep. 2001, *A. Montecchi 2344* (OSC).

**ROMANIA.** Dep. Harghita, pag. Ruganesti, 30 Aug. 1973, *Pap* (CLA).

### 10. *Statesia pompholyx* (Tul. & C.Tul.) Castellano, T.Lebel, Davoodian & K.Hosaka, *comb. nov.*

**Registration identifier: IF557964.**

*Hysterangium pompholyx* Tul. & C.Tul., *Ann. Sci. Nat. Bot. ser.* 2, 19: 375 (1843). MB186665. — **Lectotype (here designated, IF555907):** France: Bois de Meudon, Apr. 1843, *L. Tulasne* (PC). **Isolectotypes:** FH; OSC159166.

*Hysterangium rubricatum* R.Hesse, *Jahrb. Wiss. Bot.* 15: 631–341, pl. XXXII (1884). MB183606.

***Description & illustration.*** See Montecchi & Sarasini (2000). **Fig. 16E.**

*Basidiomata* 1–1.5 (–4) cm wide, reniform, globose to depressed, peridial surface white and yellow-brown, reddish brown to dark brown when fresh, floccose. *Gleba* at first white, then pale reddish brown, brown or olive brown when dried; locules elongate, partially filled. *Rhizomorphs* numerous, less than 1 mm thick, adherent to all areas of the peridium, concolorous with peridium. *Columella* gelatinous, distinct, dendroid, translucent.

*Peridium* not separable from gleba, a single layer, 200–250 µm thick, of dark reddish brown, thin-walled, polyhedral cells, up to 50–70 µm wide, abundant crystalline particles scattered throughout, some hyphal ends on outer edge with oxalate crystals, clamp connections common. *Trama* 25–100 µm thick, of hyaline, compactly interwoven hyphae, 2–4 µm wide, in a gelatinized matrix, clamp connections absent. *Basidia* not rehydrating well, hyaline, more or less cylindrical, 35–40 × 7–8 µm, 2-spored. *Spores* broadly fusiform, 16.8–18.6 × 5.8–7.0 µm, mean = 18.1 × 6.2 µm, Q = 2.5–2.9 (–3.2), $Q_{mean}$ = 2.8, asymmetrical, at first smooth, verrucose at maturity, apex blunt, base distinctly pedicellate. Spore wall up to 1.0 µm thick, sometimes thicker at apex. Utricle distinct, roughened or wrinkled, 1 µm thick, spores often stuck together in pairs from mid-spore to base. Spore color in KOH pale brown singly, pale brown in mass.

***Ecology & distribution.*** Hypogeous; probable mycorrhizal associates *Carpinus*, *Crataegus*, *Fagus*, *Corylus* and *Quercus*; March through November.

***Notes.*** We studied authentic Hesse material identified as *Hysterangium rubricatum* from the Farlow herbarium and found it conspecific in all characters. Tulasne & Tulasne (1843) lists locations as Meudon (southwest suburbs of Paris) and Fleury (in southwest France) in April through August without designating a specific collection. We choose material available from PC from the first mentioned location in the appropriate year as the lectotype, isotypes are also in FH and OSC.

*Statesia pompholyx* has a single-layered peridium, similar to *S. zelleri* but the structure of the peridium in *S. pompholyx* is of polyhedral cells, while the peridium of *S. zelleri* is composed of compact hyphae 5–8 µm wide. In addition, the spores of *S. pompholyx* are much longer but thinner than spores of *S. zelleri*.

***Etymology.*** Greek, "blister" or "bubble," possibly in reference to the roughened and wrinkled utricle surrounding the spore.

***Additional material examined.***

**GERMANY.** No locality (FH, Herb. Hesse, identified as *H. rubricatum* by Hesse; OSC159167). Saarland, Bierbach, 23 May 1972, *G. Gross 495* (OSC).

### 11. *Statesia zelleri* Castellano, T.Lebel, Davoodian & K.Hosaka, *sp. nov.*

**Holotypus:** USA: Arizona, Cochise Co., Coronado National Forest, south of Cave Creek, elevation 7500 ft., 27 Apr. 1986, *J. States AHF 602* (OSC159159).

**Registration identifier: IF557963.**

*Basidiomata* up to 1.8 cm wide, subglobose, white with pale ochraceous patches, mottled white and brown when dried, surface tomentose with much adherent soil. *Gleba* bright ochraceous when fresh, cinnamon brown when dried; locules irregular, filled at maturity, $FeSO_4$ deep blue green, in KOH slightly sordid. *Rhizomorphs* few, small, attached to base, concolorous with peridium. *Columella* cartilaginous, dendroid, arising from a sterile base, narrow, greenish gray to translucent when fresh, reddish brown when dried. *Odour* not recorded. *Taste* not recorded.

*Peridium* separable from gleba, a single layer, 300–400 µm thick, of hyaline to pale brown, thin-walled, agglutinated, irregularly shaped, compactly interwoven hyphae, 5–8 µm in diam., numerous crystalline particles scattered across cells, clamp connections absent. *Trama* 20–40 µm thick, of hyaline, interwoven hyphae 1–3 µm in diam., in a gelatinized matrix, clamp connections absent. *Basidia* hyaline, elongate, thin-walled, clamped at base, 30 × 5 µm, 2-spored. *Spores* broadly ellipsoid to irregularly shaped; apex obtusely blunt to slightly papillate, base pedicellate, 1.2 × 2.3 µm, slightly asymmetrical, 13.9–16.2 × 6.4–7.0 µm, mean = 14.9 × 6.8 µm with base, Q = 2.0–2.3, $Q_{mean}$ = 2.2, smooth, in KOH pale green singly, pale brown or buff in mass, walls up to 1 µm thick, slightly thicker at apex, utricle absent or inconspicuous, spores adherent to each other by way of what appears as a mucilaginous substance on the spore wall. **Fig. 16F.**

***Diagnosis.*** *Statesia zelleri* has a single-layered peridium similar to *S. calcarea* and *S. pompholyx*, but the peridium of *S. pompholyx* is composed of parenchyma-like cells compared to the interwoven hyphae composition of the peridium of both *S. calcarea* and *S. zelleri*. The spores of *S. zelleri* (mean = 14.9 × 6.8 µm) are wider and thus squatter than those of *S. calcarea* (mean = 15.4 × 5.8 µm). In addition, the spores of both *S. calcarea* and *S. pompholyx* appear distinctly verrucose beneath the utricle while the spores of both *S. cazaresii* and *S. zelleri* appear smooth.

***Ecology & distribution.*** Hypogeous, embedded throughout a mat of white rhizomorphs and mycelium, in association with *Quercus arizonica*, *Q. garryana* and other *Quercus* spp.; April, May in Arizona; October in Oregon.

***Notes.*** *Statesia zelleri* occurs associated with *Quercus* spp. in dry habitats in Oregon and Arizona. *Statesia cazaresii* also occurs with *Quercus* spp. in Mexico. *Statesia calcarea* and *S. pompholyx* occur in Europe in more mesic habitats with *Fagus* spp.

***Etymology.*** Specific epithet is in honour of Sanford M. Zeller, former Professor at Oregon State College (now University), preeminent truffle mycologist of his era.

***Additional materials examined.***

**USA.** Cochise Co., nr Nicksville, Carr Canyon, 11 May 1995, *B. Friedman F4875* (OSC159161); Coconino Co., Coconino National Forest, Oak Creek Canyon, 18 Sep. 1988, *J. States* (OSC159160); Oregon, Linn Co., Oct. 1922, *S.M. Zeller 2583* (NY; OSC159162).

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# *Hibbertia archeri* (Dilleniaceae), a new and rare species from Western Australia with transcontinental affinities

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**Abstract:** *Hibbertia archeri* T.Hammer & K.R.Thiele is described here as new based on specimens from two populations north-east of Esperance, Western Australia. The species is closest morphologically to *H. devitata* Toelken in South Australia and Victoria, which is part of the *H. stricta* (R.Br. ex DC.) F.Muell. morphological species group in *H.* subg. *Hemistemma* (Juss. ex Thouars) J.W.Horn.

**Keywords:** Dilleniaceae, *Hibbertia*, new species, taxonomy, Western Australia

## Introduction

During the course of determining *Hibbertia* specimens at AD for a *Flora of Australia* project on the genus, the primary author discovered an interesting specimen collected north-east of Esperance, Western Australia by W.R. Archer in 1990. Recollection efforts by E.D. Adams and M. Hoggart in the spring of 2021 were successful and uncovered a second population. This entity is clearly very distinct from all other Western Australian species and can be readily distinguished from its presumed relatives in eastern Australia (discussed below). It is formally described here as *H. archeri* T.Hammer & K.R.Thiele.

## Materials and Methods

This study was based on examination of dried specimens at AD and PERTH.

## Taxonomy

***Hibbertia archeri*** T.Hammer & K.R.Thiele, ***sp. nov.***

**Holotypus:** [precise locality withheld for conservation reasons] c. 5 km S of Mt Buraminya, 14 Oct. 2021, *E.D. Adams & M. Hoggart EA 958* (PERTH 9389571). **Isotypi:** AD, CANB.

Erect *shrubs* to 0.4 m high; branchlets sparsely to moderately pubescent with spreading to antrorse fascicled hairs. *Leaves* erect and slightly incurved towards the apex, scattered; *petiole* 0.5–0.8 mm long, abaxially glabrous, adaxially shortly pubescent with antrorse 1–3-armed fascicled hairs, axils with a tuft of straight simple hairs to 0.4 mm long; *lamina* linear, 4–8.5 mm long, 0.9–1.5 mm wide, the margins strongly recurved and obscuring all but the midrib abaxially; adaxial surface flattened, ± smooth or obscurely pale-tuberculate, sparsely hairy with appressed and antrorse 1–3-armed fascicled hairs; abaxial surface hidden beneath the tightly recurved margins, densely hairy (seen by dissection); midrib prominent, with sparse antrorse fascicled hairs, becoming ± glabrous with age; apex obtuse to bluntly acute, terminated by a few minute hairs or papillae in young leaves. *Flowers* pedicellate, single, axillary near the apex of the stems; *pedicels* 5–10 mm long, with indumentum as for branchlets; *primary bract* immediately below the calyx, linear, 2–3 mm long, leaf-like with recurved margins, sparsely hairy with appressed and antrorse 1–3-armed fascicled hairs; *secondary bracts* absent. *Sepals* 5, ovate to obovate, acute to obtuse-apiculate, the inner sepals broader and more obtuse than the outer, 5.5–7.5 mm long, 3–3.5 mm wide, abaxially sparsely to moderately pubescent with short, retrorse, hooked hairs underlain by very small antrorse fascicled hairs, adaxially glabrous except for a few hairs towards the apex; midribs not prominent; margins pale. *Petals* 5, yellow, obovate, 8–8.5 mm long, emarginate. *Stamens* (12–) 14–19, all on one side of the gynoecium, ± erect; filaments ± free to base, 1.5–1.9 mm long; *anthers* narrowly oblong, 2.2–2.6 mm long, dehiscing by introrse, longitudinal slits; *staminodes* absent. *Carpels* 2; *ovaries* compressed-ovoid, 1.6–1.8 mm long, densely pubescent; *styles* 4.8–5 mm long, inserted almost horizontally below the carpel apex then ascending and protruding outside and above the stamens. *Ovules* 6 (–9) per carpel, marginal. *Fruiting carpels* and *seeds* not seen. **Fig. 1.**


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**Fig. 1.** *Hibbertia archeri*. **A**, **B** Flowering morphology; **C** habit; **D** habitat. Photos: E.D. Adams.

***Diagnostic features.*** *Hibbertia archeri* can be diagnosed by the following combination of characters: leaves ericoid (with the margins strongly recurved to the midrib and the true abaxial surface hidden), the indumentum consisting of antrorse fascicled hairs with 1–3 arms; flowers pedicellate, the primary bract leaf-like and immediately below the calyx; sepals ovate to obovate, abaxially with retrorse hooked hairs; stamens 12–19, erect and arranged on one side of the gynoecium; carpels 2, densely pubescent, with styles 4.8–5 mm long.

***Phenology.*** Flowers in October and November.

***Distribution & habitat.*** *Hibbertia archeri* is known from two sites north-east of Esperance (Fig. 2), where it occurs in shrublands with *Melaleuca hamata*, *Halgania cyanea*, *Acacia bracteolata*, *Acacia cupularis*, *Coopernookia strophiolata*, *Lomandra collina*, *Pultenaea elachista*, *Eremophila psilocalyx* and *Triodia scariosa* on grey to red sandy loams over calcrete.

***Conservation status.*** Currently known from only two populations c. 40 km apart. The region where the species occurs is largely uncleared but has very few tracks and is relatively sparsely collected. While much of the area has loamy woodland soils unsuitable for the species, there are likely to be other suitable patches of habitat (with lighter soils) in the area, and it may be locally widespread. We recommend that it be provisionally listed as Priority One under the Conservation Codes for Western Australian Flora (Smith & Jones 2021), and further surveys be conducted in suitable habitat to determine its true status.

***Etymology.*** The epithet honours William R. Archer, a prolific plant collector from Esperance, W.A., who made the first collections of the species and recognised it as new.

***Taxonomic notes.*** Although *Hibbertia archeri* has no close affinities in Western Australia, it is broadly similar to four other named Western Australian species (*H. psilocarpa* J.R.Wheeler, *H. andrewsiana* Diels, *H. oligantha* J.R.Wheeler and *H. tuberculata* K.R.Thiele) that have the same stamen and style arrangement and disposition as *H. archeri*, i.e., with stamens all on one side of the two carpels and with both stamens and styles erect, rather than curved over the short, curved styles (like a hand of bananas), as in most Western Australian species with a zygomorphic androecium. These four species, like *H. archeri*, occur along the Western Australian south coast and hinterland (Wheeler 2004; Thiele 2019). They have, however, strictly glabrous carpels, while the carpels in *H. archeri* are densely pubescent.

*Hibbertia archeri* is most similar to members of the *H. stricta* (R.Br. ex DC.) F.Muell. morphological species group from eastern Australia (Toelken 2010). Within this group, it is most similar to *H. devitata* Toelken, a common species that occurs from the Eyre Peninsula, South Australia, to western Victoria (Fig. 2). *Hibbertia devitata* is very similar in leaf morphology and indumentum to *H. archeri*, having linear ericoid leaves with a prominent midrib, an intrapetiolar tuft of hairs < 0.4 mm long (sometimes absent in *H. devitata*), and fascicled hairs on branchlets, leaves and sepals. *Hibbertia devitata* can be distinguished from *H. archeri* by its usually sessile flowers, outer sepals lanceolate with a distinct ridge for most of their length and typically longer than the inner sepals, 1–25-armed fascicled hairs on the branchlets, leaves and sepals, and (5) 6–8 (–12) stamens (Toelken 2010). Some populations of *H. devitata* lack hooked hairs on the sepals. Atypical populations of *H. devitata* noted by Toelken (2010) clearly lack other characters that define and are consistent for *H. archeri*. For instance, a robust form of *H. devitata* that occurs on higher parts of the Gawler Ranges near Scrubby Peak has up to 12 stamens, but this form lacks a pedicel and hooked hairs, and has much larger spreading fascicled hairs with 12–25 arms. Atypical pedicellate specimens of *H. devitata* (with pedicels to 14 mm long) have been recorded from southern Eyre and Yorke peninsulas and Kangaroo Island, but these typically have glabrous or glabrescent sepals without hooked hairs.

*Hibbertia riparia* (R.Br. ex DC.) Hoogland and *H. setifera* Toelken have been included with *H. devitata* in the past (Toelken 2010) and are readily distinguished from *H. archeri*. *Hibbertia riparia* has straight simple hairs on the branches, leaves and sepals, intrapetiolar tufts of hairs to 2 mm long, and leaf midribs that are not prominent. *Hibbertia setifera* has very densely hairy leaves and sepals with spreading fascicled hairs that are of two distinct sizes on the sepals, with robust larger hairs with up to 16 arms overtopping smaller hairs with up to 10 arms. Both species have sessile flowers and lack hooked hairs on the sepals. The *H. stricta* group is currently under revision by H.R. Toelken (AD) with many new species likely to be described from eastern Australia. *Hibbertia archeri* is distinct from these prospective species, which will be dealt with in a forthcoming publication (H.R. Toelken, pers. comm.).

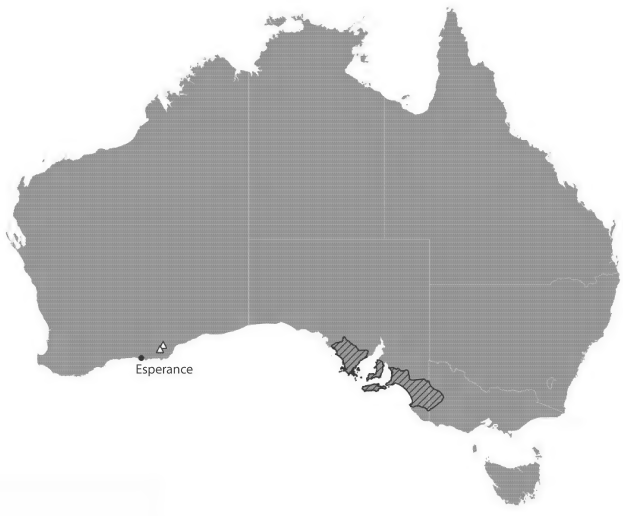


**Fig. 2.** Map of occurrences of *Hibbertia archeri* (triangles) and the distribution of *H. devitata* (diagonal shading) based on specimens at AD and PERTH.

*Hibbertia* is approximately equally diverse in south-western and eastern Australia. Taxonomic work hitherto has been divided, with J.R. Wheeler and subsequently K.R. Thiele at PERTH, and H.R. Toelken at AD, describing many new species from western and eastern Australia, respectively; there has been no consistent continental-scale account of the genus since that of Bentham (1863). A consequence of this geographic split in work has been that informal species-groups have been recognised in each area, with little understanding of relationships of species between the areas. *Hibbertia archeri* is one of the few species occurring in south-western Western Australia that is presumed to belong to what has been previously considered an 'eastern' species group (the '*H. stricta* group' of Toelken 2010). The other Western Australian species with ericoid leaves and erect stamens on one side of two carpels (*H. psilocarpa*, *H. andrewsiana*, *H. oligantha* and *H. tuberculata*) are also likely to be more closely related to eastern Australian species than they are to others in Western Australia (Thiele 2019). Future work on *Hibbertia* by the present authors, including the preparation of a complete *Flora of Australia* account and the development of a near-complete phylogeny, will allow a better assessment of relationships between eastern and western Australia in this important Australian genus and help resolve its biogeographic history across the continent.

### *Other specimens examined*

WESTERN AUSTRALIA. [Precise localities withheld for conservation reasons] c. 5 km WSW of Mt Willgonarinya, 3 Nov. 1990, *W.R. Archer 3119017* (AD); c. 5 km WSW of Mt Willgonarinya, 14 Oct. 2021, *E.D. Adams & M. Hoggart EA 953* (PERTH).

## Acknowledgements

The authors thank the curators and staff of AD and PERTH, Hellmut Toelken (Adelaide, SA) for helpful discussions, Emma Adams and Mary Hoggart (Esperance, WA) for collecting material of and photographing *Hibbertia archeri*, and William Archer for detailed discussions and helping to locate populations he had last visited many years ago. TAH is supported through a Postdoctoral Fellowship to complete the project "Delineating the diversity of Dilleniaceae: a revisionary synthesis of *Hibbertia* for the *Flora of Australia* and investigations into its taxonomy, systematics, evolution and biogeography", which is funded by the Australian Government's Australian Biological Resources Study (ABRS) National Taxonomy Research Grant Program.

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# *Swainsona picta* (Fabaceae), a new species from the Yalgoo bioregion, Western Australia

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**Abstract:** The morphology of specimens collected near and on the Karara mining tenancy in the Yalgoo bioregion of Western Australia was evaluated and support the recognition of a new species, herein named *Swainsona picta* R.W.Davis & T.Hammer. The morphological differences between the new species and its presumed close relatives are discussed, and an identification key is given.

**Keywords:** Fabaceae, new species, *Swainsona*, taxonomy, Western Australia

## Introduction

A specimen collected by botanical consultants C. Godden and J. Hruban in 2020 from the Yalgoo bioregion of Western Australia, near the Karara mine, was deposited at the Western Australian Herbarium (PERTH) and subsequently given the phrase name *Swainsona* sp. Karara (*C. Godden & J. Hruban 24-26*). A subsequent trip in 2021 to find new populations outside of the mining area by J. Hruban and M. Hrubanová was successful, and a second specimen was collected. In the present study, the morphology of these specimens was evaluated and found to support the recognition of this phrase-named taxon as a new species, which is formally described here as *Swainsona picta* R.W.Davis & T.Hammer.

## Taxonomy

***Swainsona picta*** R.W.Davis & T.Hammer, ***sp. nov.***

**Holotypus:** 45 km ENE of Perenjori, Karara Rangeland Park, 24 Aug. 2021, *J. Hruban & M. Hrubanová MJ21-02* (PERTH 09433392). **Isotypus:** CANB [to be distributed].

*Swainsona* sp. Karara (*C. Godden & J. Hruban 24-26*) Western Australia Herbarium, *FloraBase* https://florabase.dpaw.wa.gov.au/ [accessed 25 Feb. 2022].

A small, open, annual *herb* to 5–15 cm high, 8–28 cm wide, with several short stems radiating from a slender taproot. *Stems* c. 0.8 mm wide, terete to slightly compressed, with fine, spreading to slightly ascending, basifixed hairs, to 1 mm long. *Stipules* ovate, 2.5–8 mm long, 2.5–6 mm wide; both surfaces evenly

### Modified key to the species of *Swainsona* in Western Australia

Couplets 10 & 11 of the key provided by Davis & Hammer (2020) require modifications as follows:

**10.** Calyx lobes clearly longer than the calyx tube; upper wing surface with curved white marking . . . . . ***S. katjarra***
**10:** Calyx lobes clearly shorter than tube; upper wing surface without markings
**11.** Leaves broadly obovate to ovate, unifoliate leaves common . . . . . ***S. unifoliolata***
**11:** Leaves narrowly lanceolate to elliptic rarely with unifoliate leaves
**11a.** Stem hairs appressed; pulvinus at base of peduncle obvious, dark in colour, hairy . . . . . ***S. oroboides***
**11a:** Stem hairs patent; pulvinus at base of peduncle not apparent . . . . . ***S. picta***

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**Fig. 1.** *Swainsona picta*. **A** habit at the type locality; **B** flower; **C** branch with two fruits. — *J. Hruban & M. Hrubanová MJ21-02*. Photos: J. Hruban & M. Hrubanová.

covered with long, fine, spreading hairs. *Leaves* 30–60 mm long, imparipinnate; petiole 20–30 mm long; lateral leaflets in 2–4 pairs, flat to slightly involute, linear to oblong (rarely obovate), 3.5–12 mm long, 0.7–3.5 mm wide, truncate to slightly emarginate, the adaxial surface mostly glabrous except for sparse, long, fine, spreading hairs towards the margins, the abaxial surface with a sparse, even covering of long, ascending, fine hairs; terminal leaflet similar in size, shape and indumentum to the lateral leaflets. *Racemes* 40–90 mm long, 1–3 (4)-flowered. *Peduncle* slender, angled, 0.6–0.7 mm wide, glabrous or with very sparse, appressed hairs; pulvinus absent or at least not obvious. *Bracts* ovate, 0.8–1.3 mm long, with sparse, fine hairs. *Flowers* purple, 6.5–7 mm long; pedicels 0.6–0.9 mm long, with dense, fine, ascending to spreading hairs; bracteoles not observed. *Calyx* with tube 1.8–2.3 mm long, slightly expanding towards the top, mostly glabrous or with a few fine hairs; calyx lobes triangular, 1.4–1.7 mm long, 0.7–0.8 mm wide, with sparse, spreading hairs along the margins. *Standard* slightly longer than broad, purple with white eyes at base, 5.8–6.5 mm long, 5.3–5.7 mm wide; claw shortly tapering, 0.8–1.3 mm long. *Wings* oblong, constricted in the middle and slightly upwardly curved, purple fading towards the base, apex margin pale mauve, 3.8–4.2 mm long, 0.7–1.3 mm deep. *Keel* boat-shaped, slightly twisted, broadest towards the middle, purple and fading white towards the base, 7–7.5 mm long, 2.3–2.5 mm deep; auricles negligible; apex sharply hooked upwards. *Ovary* ellipsoid, c. 2.5 mm long, with a dense covering of spreading, fine, silky hairs to 2 mm long, the base of the hairs with distinct, purple-speckled markings. *Ovules* numerous. *Style* flattened, short, stout, and strongly upwardly curved, c. 3 mm long, with hairs along the adaxial edge, tuft of hairs on the abaxial edge present; apex geniculate. *Fruit* pendulous, ellipsoid to obovoid, 18–22 mm long, inflated, dorsally compressed, stipe elongated, 4.2–4.6 mm long, hairs long, fine, spreading, to 2 mm long, with prominent, purple, tuberculate bases. **Fig. 1.**

***Diagnostic features.*** *Swainsona picta* can be separated from all members of the genus by the following combination of characters: stems with fine, spreading hairs; stipules ovate; leaflets in 2–4 pairs, linear to oblong; pulvinus absent at base of peduncle; style geniculate, with an abaxial tuft of hairs at the apex; mature fruits pendulous, ellipsoid to obovoid, 18–22 mm long, with a long stipe 4.2–4.6 mm long, appearing spotted due to the distinctive, purple, tuberculate bases of the long (to 2 mm), spreading hairs.

***Distribution and habitat.*** The two recorded collections of *Swainsona picta* occur on Karara Station with one population within the Karara mine tenancy. It occurs in open shrublands or low woodlands of *Acacia umbraculiformis*, *Acacia kockii*, *Hakea recurva* and *Solanum lasiophyllum* over annual forbs and grasses on rocky slopes with red-brown sandy loam amongst decomposing granite.

***Phenology.*** Both collections of *Swainsona picta* have been made in August when the plants were in flower and with the fruits almost mature or in early stages of development.

***Conservation status.*** Listed under Department of Biodiversity, Conservation and Attractions' Conservation Codes for Western Australia, as Priority One under the name *Swainsona* sp. Karara (*C. Godden & J. Hruban 24-26*). Only two populations have been recorded; a single plant was recorded on the original specimen's label (PERTH 09315551), and "20+ plants" were recorded on the type specimen's label (PERTH 09433392). Potential threats are likely to be from mining activity and grazing by feral animals.

***Notes.*** *Swainsona picta* is similar in morphology to a group of seven species within the genus, comprising *S. flavicarinata* J.M.Black, *S. disjuncta* Joy Thomps., *S. cyclocarpa* F.Muell., *S. halophila* Joy Thomps., *S. katjarra* R.W.Davis & T.Hammer, *S. unifoliata* F.Muell. and *S. oroboides* Benth. All these species can be recognised by having a geniculate style and a tuft of hairs on the abaxial surface near the apex of the style (see Fig. 1 in Davis & Hammer 2020).

*Swainsona picta* is most similar to *S. oroboides*, which is widely distributed in the Eremaean Botanical Province of Western Australia (Beard 1990), with one record from Burnerbinmah Station in the Yalgoo bioregion. *Swainsona picta* can be clearly differentiated from *S. oroboides* by having long, basifixed, spreading hairs to 1 mm long on the stems, no obvious pulvinus at the base of the peduncle, and an elongated stipe. *Swainsona oroboides* has appressed hairs on the stems, which are basifixed and sometimes semi-medifixed, a conspicuous, hairy and dark-coloured pulvinus, short stipe, and fruit with long, fine, ascending hairs, lacking the coloured tubercles at the base.

***Etymology.*** From the Latin *pictus* (painted), in reference to the numerous, prominent, purple spots on the maturing fruit.

***Proposed vernacular name.*** Painted swainsona.

***Additional specimen examined***

Karara Station, 16 Aug. 2020, *C. Godden & J. Hruban 24-26* (PERTH).

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# A review of the *Spyridium eriocephalum* complex (Rhamnaceae: Pomaderreae)

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**Abstract:** *Spyridium eriocephalum* Fenzl and related taxa are described and illustrated, following a recent molecular analysis of the genus. The variety of the species endemic to Kangaroo Island is raised to specific rank, as *S. glabrisepalum* (J.M.Black) Kellermann & C.Clowes. The following new taxa are published: *Spyridium latifolium* Kellermann from the Fleurieu Peninsula (S.A.) and *S. undulifolium* Kellermann & S.A.J.Bell from the Goulburn River area (N.S.W.). The population of an entity with historical collections close to the latter species requires re-collection and further examination before a decision can be made as to its status; it is provisionally given the phrase name *Spyridium* sp. Dingo Creek (*T. Tame 1011*) Kellermann. *Spyridium eriocephalum s.str.* is widespread, mainly in mallee areas of southern Australia, extending to the Central Mallee in New South Wales, an occurrence in the Victorian Alps, as well as two locations in Tasmania. A key to all taxa of the species-complex is provided.

**Keywords:** New species, typification, Rhamnaceae, *Spyridium*, New South Wales, South Australia, Tasmania, Victoria

## Introduction

Fenzl (1837) erected the genus *Spyridium* Fenzl with one species, *S. eriocephalum* Fenzl, in his enumeration of Australian Rhamnaceae. The species was described from a collection made along the Derwent River, Hobart, Tasmania. *Spyridium eriocephalum* is quite widespread in mallee areas of south-eastern Australia from Yorke Peninsula, South Australia, to Long Forest, Victoria, and the central mallee region in New South Wales, but also occurs in other habitats: at the type locality in Tasmania it grows in open eucalypt woodland with impoverished soils and in one location in the Victorian Alps in a riparian habitat (Curtis 1956; Canning & Jessop 1986; Walsh & Udovicic 1999; Harden 2000; M. Wapstra, pers. comm. Dec. 2021).

*Spyridium eriocephalum* is morphologically close to *S. phylicoides* Reissek, but differs by its narrower vegetative leaves with a distinct recurved tip, a dense indumentum of simple and stellate hairs on young branches, as well as the absence of white felty floral leaves, subtending the flower-head. *Spyridium phylicoides* occurs in South Australia from the cliffs of the Nullarbor Plain throughout Eyre Peninsula, Yorke Peninsula, Kangaroo Island and to the edge of the Murray Mallee. It consistently has 2–4 small floral leaves, which are usually shorter than the vegetative leaves and have a white indumentum on the upper surface; young branches have an indumentum of only stellate hairs. Both *S. eriocephalum* and *S. phylicoides* have stipules that are fused for more than half of their length.

*Spyridium eriocephalum* var. *glabrisepalum* J.M.Black was described by Black (1926) from Kangaroo Island. This variety was distinguished from the typical var. *eriocephalum* by its distinctive glabrous and viscid sepals. It is restricted to the eastern half of the island, excluding the Dudley Peninsula.

For some time, collections from the Fleurieu Peninsula, South Australia, were also identified as either *Spyridium eriocephalum* var. *eriocephalum* or var. *glabrisepalum*. However, while they have viscid flower-heads, these specimens have hairy sepals and also broader leaves. During work on the *Flora of Australia* treatment of Rhamnaceae (Kellermann *et al.* (2022) and in prep.), these specimens from near Goolwa, Finniss and Bullock Hill were separated from *Spyridium eriocephalum*. Collections from two locations in the Goulburn River catchment, New South Wales, labelled as *Spyridium* aff. *eriocephalum* or *S.* aff. *scortechinii* were also set aside as being atypical of *S. eriocephalum* and in need of further research.


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Clowes *et al.* (2022) undertook a molecular systematic analysis of the genus *Spyridium* and included the two varieties of *Spyridium eriocephalum*, as well as samples from Fleurieu Peninsula and from one of the Goulburn River entities, as *Spyridium* sp. Finniss (*J. Kellermann 455*) Kellermann and *Spyridium* sp. Wollar (*E.J. Constable s.n.*; NSW16590) Kellermann, respectively. The results clearly showed that *Spyridium eriocephalum* var. *eriocephalum*, *S. eriocephalum* var. *glabrisepalum* and *Spyridium* sp. Wollar are unrelated, as they were placed in separate clades in the analysis of nrDNA. In this paper, we raise var. *glabrisepalum* to species rank as S. *glabrisepalum* (J.M.Black) Kellermann & C.Clowes, and describe the entity from Wollar as the new species *S. undulifolium* Kellermann & S.A.J.Bell.

While the analysis placed *Spyridium* sp. Finniss into the same clade as var. *glabrisepalum* in a polytomy with several other morphologically distinct species, the morphological differences, its disjunct location and unusual habitat justify the description of this phrase name taxon as a new species, *S. latifolium* Kellermann.

The second entity from the Goulburn River area was not included in the sampling of Clowes *et al.* (2022), as there have been no collections for over 30 years. Even though it grows close to *S. undulifolium* (c. 50 km), it exhibits some morphological differences and reportedly occurs in distinctly different habitat (riparian zones on alluvium vs exposed *Triodia* hills on shale soils). Because it is only known from three specimens, all collected in the same location in the 1980s, and since we cannot rule out that it is only a form of *S. undulifolium*, we refrain from describing it formally. Instead, we propose the phrase name *Spyridium* sp. Dingo Creek (*T. Tame 1011*) Kellermann. The location should be surveyed for plants of this entity, as more collections will enable a better assessment of this phrase name taxon.

## Methods

The study was based on the examination of herbarium specimens from AD, CANB, HO, K, MEL, NSW and W. Fieldwork was undertaken in South Australia, western Victoria and the Wollar region, New South Wales, to collect fresh material, assess habitat and photograph live plants.

## Taxonomy

### 1. *Spyridium eriocephalum* Fenzl

in Endl. *et al.*, *Enum. Pl.* 24 (1837). — *Cryptandra eriocephala* (Fenzl) Hook.f., *Bot. Antarct. Voy. III. (Fl. Tasman.)* 1: 72 (1857). — *Spyridium eriocephalum* var. *eriocephalum*: J.M.Black, *Fl. S. Austral.* 3: 369 (1926). — **Type citation:** "*Derwent - River.* (Ferd. Bauer.)". **Holotype:** N. Holl. ad Derwent-River, *F. Bauer s.n.* [actually collected by *R. Brown*] (W0056002, ex Herb. Bauer). **Possible syntypes:** Derwent, 1804, *R. Brown Iter Austral. 5355* (BM); Derwent, *R. Brown Iter Austral. 5355* (K); Derwent River, Tasmania, *R. Brown Iter Austral. 5355* (E00770108); Derwent, *R. Brown s.n.* (K; E00770110; MEL2103316; NSW592497, ex MEL; WELT.SP096065); Van Diemen's Island, Derwent River, 1804, *R. Brown s.n.* (CANB278617;

**Key to species of the *Spyridium eriocephalum* complex**

**1.** Floral leaves (subtending the flower-head) with dense white indumentum, usually shorter than vegetative leaves; young branches with an indumentum of dense stellate hairs . . . . . ***Spyridium phylicoides***

**1:** Floral leaves glabrous, green; young branches with simple and stellate hairs

**2.** Sepals glabrous outside; flower-heads, bracts, stipules and other parts of the plants quite resinous . . . . . 2. ***Spyridium glabrisepalum***

**2:** Sepals with an indumentum of simple and stellate hairs outside; plants resinous or not

**3.** Leaves ovate, elliptic to obovate (sometimes narrowly), 1–4.2 mm wide; margins recurved to slightly revolute, the lower surface often visible; plants resinous . . . . . 3. ***Spyridium latifolium***

**3:** Leaves linear to very narrowly ovate or very narrowly elliptic, 0.3–1.1 (–2.3) mm wide; margins strongly recurved or revolute, usually obscuring the lower surface of the leaf; plants not particularly resinous

**4.** Leaf apex with a distinctly recurved tip; stipules 1–4 mm long; flowers small, hypanthium tube < 0.8 mm long, sepals 0.5–1 mm long; inflorescence axis 1.5–7 (–10) mm long; seeds covered with dark mottles . . . . . 1. ***Spyridium eriocephalum***

**4:** Leaf apex straight; stipules 2.5–5 mm long; flowers larger, hypanthium tube > 1mm long, sepals 0.6–1.3 mm long; inflorescence axis (3.5–) 7–18 mm long; seeds plain with only few dark mottles

**5.** Habit erect to spreading; leaves wavy or curved on young shoots; flower-heads 7–14 mm diam. . . . . 4. ***Spyridium undulifolium***

**5:** Habit lax or drooping; leaves very thin and narrow, straight when young; flower heads small, 4–6 mm diam. . . . . 5. ***Spyridium* sp. Dingo Creek**

NSW592496, ex BM); *s.loc.*, *R. Brown s.n.* (NSW 592495, ex MEL).

*Spyridium uncinatum* Reissek, *Linnaea* 29: 289 (1857). — **Type citation:** "Mallee-Scrub et Murray-Scrub (Dr. F. Mueller)". — **Lectotype (here designated):** Mallee Scrub, *F. Mueller s.n.* (W0056001, annotated "Spyridium uncinatum Reiss & Müll." by Reissek). **Isolectotype:** Mallee Scrub, [*F. Mueller s.n.*] (MEL2104227, annotated "Trymalium uncinatum Ferd Mueller" by Mueller and "Spyridium uncinatum Reiss & Müll." by Reissek). **Residual syntypes:** In the Mallee Scrub towards Lake Tyrell, Victoria, *F. Mueller s.n.* (K000732092, ex Herb. Hooker, with detailed illustration of flower, annotated "Trymalium uncinatum" by Mueller); Murray Scrub, [E of the Lofty Ranges, *F. Mueller s.n.*] (MEL2104221, annotated "Pomaderris (Trymal.) uncinata FerdMll" by Mueller). **Possible syntype:** Ad ostium fluminis Murray, May 1849, *Wuerth* (MEL2104228, annotated "Spyridium eriocephalum Fenzl var uncinatum" by Mueller).

*Spyridium prostratum* Reissek, *Linnaea* 29: 284 (1857). — *Pomaderris prostrata* F.Muell. ex Reiss., *Linnaea* 29: 284 (1857), *nom inval. pro syn.* — **Type citation:** "Van Diemensland (C. Stuart)". **Lectotype (here designated):** Plantae Müllerianae, Van Diemensland, *C. Stuart* (W0056000, annotated "Spyridium prostratum Reiss. & Müll." by Reissek and "Pomaderris (Trymal.) prostrata F. Müll." by Mueller). **Isolectotype:** Van Diemens Land, Oct. 1848, *C. Stuart* (MEL2094429, annotated "Trymalium (Pomaderris) prostratum FerdMll." by Mueller). **Possible syntypes:** South Esk, *C. Stuart 100* (HO42636, with Gunn number 1044/1842); South Esk River, nr. Evandale, Nov. 1848, [*C. Stuart*] *s.n.* (MEL2104177, with second label "Habit prostrate, South Esk River, (83), Oct. 24th, fl all seasons").

*Trymalium uncinatum* F.Muell., *Second Gen. Rep. Gov. Botanist Veg. Colony* 11 (1854), *nom. nud. & inval.*

*Spyridium phylicoides auct. non* Reissek: Canning in Jessop & Toelken, *Fl. S. Austral.* 2: 815 (1986), *pro parte*.

*Shrubs* to 1.3 (–1.8) m high; young stems densely pubescent with white to rusty loosely appressed to spreading long simple over shorter stellate hairs, sometimes resinous (esp. the stipules). *Leaves* alternate: *stipules* triangular to broadly triangular, 1–4 mm long, fused for more than half of their length to almost entirely, reddish-brown, glabrous or with hairs along midrib and ciliate towards apex; *petiole* 0.4–1.3 mm long, glabrous; *lamina* very narrowly ovate to linear, 3.2–14 mm long, 0.3–1.1 (–1.6) mm wide, base obtuse to cuneate, or cordate, margins strongly recurved to revolute, apex acute to acuminate, ending in a long brown recurved tip, upper surface glabrous, smooth to muricate, lower surface largely obscured by margins, with dense white stellate hairs, midrib also with long appressed white simple hairs. Densely felty *floral leaves* absent, inflorescence subtending leaves similar to vegetative leaves. *Inflorescence* a dense axillary or terminal head of up to 25 cymosely arranged ± sessile flowers, 3–7 (–10) mm diam.; inflorescence *axis* 1.5–7 (–10) mm long, medium to densely pubescent with white hairs, sometimes rusty; *bracts* ovate to orbicular, 1.4–2.5 mm long, mostly glabrous, margins ciliate. *Flowers* white. *Hypanthium tube* 0.3–0.8 mm long, 0.8–1.5 mm diam., with sparse medium dense long simple hairs over smaller stellate hairs, base similarly pubescent. *Sepals* 0.5–1 mm long with an indumentum of medium dense to dense, simple and stellate hairs. *Petals* 0.35–0.6 mm long, cucullate, distinctly clawed; limb:claw ratio c. 4:1. *Stamens* subequal to the petals, 0.3–0.5 mm long; *anthers* 0.15–0.2 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube, which is notched adjacent to the stamens. *Ovary* inferior, carpels 3, summit with dense erect stellate and simple hairs; *style* 0.5–0.9 mm long, entire, slightly 3-lobed at apex. *Fruits* obovoid to ellipsoid, (1.5–) 1.7–2.6 mm long, 1.3–1.5 mm wide, consisting of 3 white papery fruitlets of which usually only 2 develop fully, torus in upper third, fruit wall ± glabrous, dark brown to black; *seeds* flattened obovoid to ellipsoid, 1.3–1.5 (–1.8) mm long, (0.6–) 0.9–1.1 mm wide, fawn to light brown with dark mottles present in some seeds, base dark brown. **Fig. 1.**

***Illustrations:*** G.M. Cunningham *et al.*, *Pl. W. New S. Wales* 477 (1981), photo; J.P. Jessop & H.R. Toelken, *Fl. S. Austral.* 2: 816, Fig. 429C (1986); G.J. Harden, *Fl. New S. Wales* 1: 369 (1990); W.R. Barker, *J. Adelaide Bot. Gard.* 16: 21, Fig. 2D (1995), stipule only; N.G. Walsh & T.J. Entwisle, *Fl. Victoria* 4: 118, Fig. 20F (1999); M.G. Corrick & B.A. Fuhrer, *Wildfl. Victoria* 199, Fig. 696 (2000), photo; M. Wapstra *et al.*, *Tasman. Pl. Names Unravelled* 246 (2010), photo; A. Prescott, *It's Blue Five Pet. Ed. 2*, 146 (2012).

***Distribution & habitat.*** The species occurs in South Australia in the Murray Mallee, east of the Mt Lofty Ranges, where it is conserved in Monarto, Ferris McDonald, Mt Boothby and Ngarkat Conservation Parks (C.P.), as well as in the Billiat Wilderness Protection Area (W.P.A.), with scattered occurrences north of Adelaide, in Stansbury Scrub on Yorke Peninsula and one record from near Kingscote on Kangaroo Island. In western Victoria it is recorded from south of the Murray River in Murray-Sunset National Park (N.P.) to the Big Desert and Little Desert areas, with a record near the Grampians; *Spyridium eriocephalum* also grows in the Long Forest area near Melton and Bacchus Marsh, and has been collected from the Inglewood-Wedderburn area and the Moroka River in Alpine N.P. In New South Wales the species only occurs in a Central Mallee area between north of Mt Hope and Griffith, where it is conserved in Round Hill and Pulletop Nature Reserves (N.R.). In Tasmania the taxon occurs on the eastern shore of the Derwent River, the type locality, in and around East Risdon State Reserve (S.R.), Hobart, and is also recorded from near Evandale, south of Launceston, possibly along the South Esk River (Fig. 7).

**Fig. 1.** *Spyridium eriocephalum* at East Risdon S.R., Tasmania (A, C), the Big Desert, Victoria (B, F, G), and Monarto C.P., South Australia (D, E). **A** Plant growing in low-nutrient sandy loam at East Risdon; **B** bush growing in deep sand in the Big Desert; **C, D** flowering and fruiting branches; **E** branch with inflorescence; **F, G** close-up of flower-heads. — B *J. Kellermann 918 & F. Nge*, D, E *J. Kellermann 635*, F *JK 913 & FN*, G *JK 909 & FN*. Photos by M. Wapstra (A, C) and J. Kellermann (B, D–G).

*Spyridium eriocephalum* mainly grows in mallee scrub and woodland, as well as heathland, usually in sandy soils, ranging from deep sand to sandy loam and sand with outcropping rocks or rocky gravel (described as sandstone, siltstone, limestone and laterite). It also sometimes occurs along rivers and in riparian habitats in similar soils.

***Phenology.*** Flowering throughout the year, mainly Aug.–Nov.

***Affinities.*** The species is similar to *Spyridium phylicoides* and *S. leucopogon* F.Muell., but differs in the absence of white floral leaves and narrower, almost linear vegetative leaves with a distinctly recurved tip. Differences to other species within the *S. eriocephalum* complex are listed below.

***Typification.*** In the protologue, Fenzl (1837) listed a specimen from Derwent River, collected by Ferdinand Bauer. Only one specimen of this collection is known at W, where Fenzl worked, and this is here accepted as the holotype of the name (see Kellermann 2020).

Together with Robert Brown, Bauer travelled in Australia as the artist on Flinders' voyage from 1801 to 1805. During Feb.–Aug. 1804, Brown went to the River Derwent region in Tasmania (Vallance *et al.* 2001); however, Ferdinand Bauer never visited this area. As such the collector information on the holotype label must be in error. We assume that Brown shared duplicates of his Tasmanian collections with Bauer and that the type specimen was accidently labelled as collected by "Ferd. Bauer".

Mabberley (2021) mentions that Bauer also illustrated plants grown from seed collected by Brown in Tasmania, after their return to London; we do not believe that the W specimen originated from cultivated material, as it is quite a large specimen from a mature shrub and very similar to the material collected by Brown in habit and flowering stage. Brown collected specimens of *Spyridium eriocephalum* at Risdon Cove or along the River Derwent (Burbidge 1955; Vallance *et al.* 2001; Kellermann 2004), where the species is still found today.

The lectotype of *Spyridium uncinatum*, designated above, is a small specimen at W that was annotated by Reissek and also has his manuscript notes attached to it, which are similar to the description in the protologue; the specimen is almost certainly a duplicate of MEL2104227. The lectotype of *S. prostratum* is a large specimen and was also annotated by Reissek, as well as Mueller.

***Conservation status.*** *Spyridium eriocephalum* is listed as Endangered under the Tasmanian *Threatened Species Protection Act 1995* (TSS 2011). Presently not listed, its status in New South Wales should be assessed, as well as the Victorian locations outside the sandy mallee areas.

***Notes.*** This widespread species is quite variable in leaf length and width, inflorescence diameter, as well as size, which varies from small almost prostrate shrublets to large and upright plants. Walsh & Udovicic (1999) note that plants from non-mallee areas tend to be taller, have longer leaves and stipules, and are more viscid than mallee plants. Some records of *Spyridium eriocephalum* have thicker and shorter, more terete leaves, but these could not be correlated to different habitat types.

Some unusual specimens are potential hybrids with other species of *Spyridium* and show intermediate characteristics, e.g. with *S. subochreatum* (F.Muell.) Reissek, the specimen of which has much wider leaves (to 2.3 mm) than *S. eriocephalum* (*M.G. Corrick 6347*; AD, MEL).

Records of this species from Eyre Peninsula and most records from Yorke Peninsula are actually *Spyridium phylicoides*, as they all have small floral leaves with a white indumentum on the upper surface. It was previously stated that there are old *S. eriocephalum* collections from near Cataract Gorge in northern Tasmania (TSS 2011), but these have all been re-determined as *S. vexilliferum* (Hook.) Reissek.

***Common name.*** Heath spyridium (FNCV 1923; Canning & Jessop 1986), heath dustymiller (Wapstra *et al.* 2005–).

***Etymology.*** The epithet is derived from the Greek ἔριον (*erion*, wool) and κεφαλη (*cephale*, head) (Stearn 1983), on account of the hairy flower-heads.

***Selected specimens examined*** (c. 270 seen)

SOUTH AUSTRALIA. Rd from Monarto South E to 'Kornheim', 14 Jan. 1977, *C.R. Alcock 5535* (AD, G); 20 km N of Blanchetown, 30 July 1981, *R. Bates 966* (AD, HO); 5 km E of Linwood, 1 km S of Light River (R.), 14 June 1999, *R. Bates 53008* (AD, HO, I, MEL, UTEP, WU, Z); Hundred of Senior, Bordertown, 10 Jan. 1964, *D. Hunt & M. Welbourn s.n.* (AD); Intersection of Ngarkat Hwy and Kirra Rd, S side of Kirra Rd, 28 Aug. 2019, *J. Kellermann 832 & F. Nge* (AD); Stansbury Scrub, 28 Aug. 1983, *W.L. Quinn 58* (AD, COLO, PRE, SMC); 1 mile [1.6 km] E of Malinong hall, c. 45 km SE of Murray Bridge, 18 Nov. 1959, *M.C.R. Sharrad 408* (AD); Murray Mallee, 0.5 km SSW of Wynarka on rd to Moorlands, 50 m E of rd, 25 Sep. 1995, *F. Udovicic 225* (AD, B, CANB); N boundary of Mt Boothby C.P., 300 m W of rd from Coonalpyn, 20 m S from Richardson Rd into park, 12 Oct. 1995, *F. Udovicic 326* (AD, CANB, MEL, PERTH, E, SI).

NEW SOUTH WALES. Round Hill Faunal Reserve (Res.) near Mt Hope, 2 Nov. 1966, *Anon. s.n.* [Mus. Appl. Arts & Sci.] (MEL, NSW); Nombinnie Mallee, Site 12, 15 Nov. 1985, *J. Benson s.n.* (NSW); Pulletop N.R., c. 20 km SW of Rankins Springs, 12 Nov. 1975, *M.D. Crisp 1456* (AD, CBG, US, BISH); Garoolgan turn-off, 22 km E of Rankins Springs to West Wyalong, 19 Nov. 1975, *M.D. Crisp 1599* (AD, CBG, US); 2 km E of Shepherds Hill, Euabalong West, 1 Dec. 1973, *G.M. Cunningham 1603 & L. Milthorpe* (NSW); 27 miles [43.5 km] from Lake Cargelligo, towards Mt Hope, 13 Sep. 1966, *M.E. Phillips s.n.* (AD, CBG); Pulletop N.R.,

32 km N of Griffith, 25 Mar. 1975, *I.R. Telford 3862 & P. Ollerenshaw* (CBG, US, BISH).

VICTORIA. Long Forest Nature Conservation Res., c. 300 m along the main tk leading N from the main carpark, just N of just over the culvert crossing the watercourse on both sides of the tk, 9 Jan. 2017, *C. Clowes CC515* (AD, MELU); 38 km N of Broken Bucket bore & 52 km S of Murrayville on Nhill rd, 1 Oct. 1979, *M.G. Corrick 6347* (AD, MEL); Big Desert, beside Murrayville-Yanak Rd about 13.9 km S of Murrayville, 25 Nov. 2010, *J.A. Jeanes 2486* (CANB, K, MEL, S); Little Desert N.P., Kiata Campground area, junction of Salt Lake Tk with Campground Tk, 29 Sep. 2017, *N.G. Karunajeewa 1613* (AD, CHR, MEL, PAL, S); Big Desert State Forest, 100 m W of Murrayville-Nhill Rd, c. 12 km S of Mallee Hwy, 6 Oct. 2019, *J. Kellermann 913 & F. Nge* (AD, MEL); Big Desert, 10 m west of Murrayville-Nhill Rd, 13 km South of Mallee Hwy, flat between dunes, 6 Oct. 2019, *J. Kellermann 918 & F. Nge* (AD, B, KUN); Little Desert N.P., at corner of Cooack Settlement Rd, 7 Oct. 2019, *J. Kellermann 947 & F. Nge* (AD, DMHN); Little Desert N.P., Cooack Settlement Rd, 1 km S from park corner towards Cooack Rd, 7 Oct. 2019, *J. Kellermann 949 & F. Nge* (AD, MEL, NY, SI); Birdcage Flora and Fauna Res., E side along Amy Johnson Hwy, 23 Sep. 2014, *R.W. Purdie 9667* (CANB, MEL); Little Desert, 6 km along W-E rd, c. 10 km N of Mitre Lake, 14 Oct. 1995, *F. Udovicic 332* (AD, CANB, MEL); Verge of Moroka R. below gorge tk, near where jeep tk from Doolans Plains approaches river, 28 Oct. 1985, *N.G. Walsh 2437* (MEL).

TASMANIA. East Risdon N.R., ridge top directly above *Eucalyptus morrisbyi* gully, 15 May 1988, *R. Burns 32* (CBG); Risdon N.R., above Tommy Bight, Jan. 2005, *M.F. Duretto 1850* (AD, B, HO, KRA, MEL); Lindisfarne, 2nd bay from Natone, 2 July 1948, *M. Hart s.n.* (HO); East Risdon N.R. on ridge opposite Zinc Works, 16 Nov. 2005, *M. Visoiu 94* (HO, K, MEL); Shag Bay, East Risdon N.R., 15 Jan. 2016, *M. Wapstra & E. Wapstra WAP01* (AD, MELU); Slope S of Tommys Bight, East Risdon N.R., 15 Jan. 2016, *M. Wapstra & E. Wapstra WAP02* (AD, MELU); Shag Bay, top side of walking tk, S side of bay, 22 Jan. 2010, *M. Wapstra 1045* (HO).

### 2. *Spyridium glabrisepalum* (J.M.Black) Kellermann & C.Clowes, *comb. & stat. nov.*

*Spyridium eriocephalum* var. *glabrisepalum* J.M.Black, *Fl. S. Austral.* 3: 369 (1926). — **Type citation:** "Kangaroo Island". **Lectotype (here designated):** Cygnet R.[iver], K.[angaroo] I.[sland], Oct. 1908, *H.H.D.G.*[*riffith*] *s.n.* (AD98132269, with annotation "Sent Melb as No. 3"). **Isolectotypes:** ?MEL.

*Shrubs* 0.6–1.2 m high; young stems densely pubescent with white loosely appressed to spreading stellate hairs, resinous. *Leaves* alternate: *stipules* triangular, 1.1–2.5 mm long, fused for half of their length or more, reddish-brown, glabrous, very resinous esp. when young; *petiole* 0.5–1.5 mm long, with stellate and longer simple hairs that continue along midrib; *lamina* narrowly ovate to narrowly elliptic or narrowly obovate, or linear, 3.8–9.8 mm long, 0.8–3 mm wide, base cuneate, sometimes obtuse or cordate, margins recurved to revolute, apex acute to acuminate, with a distinctly recurved tip, upper surface glabrous, smooth to papillose, lower surface often obscured by margins, with dense white stellate hairs, midrib also with long appressed white or sometimes rusty simple hairs. Densely felty *floral leaves* absent, inflorescence subtending leaves similar to vegetative leaves. *Inflorescence* a dense axillary or terminal head of up to 20 cymosely arranged ± sessile flowers, 2.5–6.5 mm diam., quite resinous; inflorescence *axis* 2–10 mm long, medium to densely pubescent with longer white hairs, over small white stellate hairs; *bracts* ovate, 1.1–2.3 mm long, mostly glabrous, margins entire. *Flowers* white to cream. *Hypanthium tube* 0.5–0.7 mm long, 1–1.4 mm diam., glabrous, with sparse long simple hairs at base. *Sepals* 0.6–0.9 mm long, glabrous. *Petals* 0.4–0.6 mm long, cucullate, distinctly clawed; limb:claw ratio c. 4:1. *Stamens* subequal to the petals, 0.3–0.65 mm long; *anthers* 0.15–0.2 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube, notched adjacent to the stamens. *Ovary* inferior, carpels 3, summit with dense erect stellate and simple hairs; *style* 0.6–0.9 mm long, entire, slightly 3-lobed at apex. *Fruits* obovoid to ellipsoid, 2.3–2.6 mm long, 1.5–1.7 mm wide, consisting of 3 white papery fruitlets, torus almost apical, fruit wall ± glabrous, with a few long simple hairs, dark brown to black; *seeds* flattened obovoid to ellipsoid, 1.3–1.5 mm long, c. 1 mm wide, fawn to light brown with dark mottles, base dark brown. **Fig. 2.**

***Distribution & habitat.*** The species is endemic to eastern Kangaroo Island, South Australia (but not the Dudley Peninsula), in the area around Cygnet River, Kingscote, Birchmore and Haines; it is conserved in Beyeria C.P. *Spyridium glabrisepalum* grows in mallee on lateritic and sandy soils, mainly on roadsides (Fig. 7).

***Phenology.*** Flowering is recorded in the second half of the year, with the majority of collections from June, Oct. and Nov.

***Affinities.*** The species can be distinguished from *S. eriocephalum* by its glabrous sepals and wider leaves. Plants are also much more resinous, especially on inflorescence and flowers, stipules and young stems.

***Typification.*** One specimen is known from J.M. Black's herbarium in AD that fits the protologue, but Black annotated on the specimen that he sent a duplicate to Melbourne. While this duplicate has not been located, we still assume that it may be present in the MEL collection. The specimen at AD is selected as the lectotype of the name.

***Conservation status.*** The species is listed as Endangered in the South Australian *National Parks and Wildlife Act 1972* and as Vulnerable in the federal *Environment Protection and Biodiversity Conservation Act 1999* (Taylor 2008, 2012).

***Common name.*** Macgillivray spyridium (Taylor 2008).

***Etymology.*** The epithet is derived from the Latin *glaber* (without hair) and *sepalum* (sepal), and refers to the glabrous sepals of the species.

**Fig. 2.** *Spyridium glabrisepalum*. **A** Plant growing near Playford Hwy, Kangaroo Island; **B** flowering branches; **C, D** young flower-heads; **E** older flower-head. — A, B, E *T.S. Te 1238*; C *D.J. Duval 3560*; Photos: South Australian Seed Conservation Centre.

***Selected specimens examined*** (c. 40 seen)

SOUTH AUSTRALIA. Beyeria C.P., along E boundary, 10 m from fire tk, 9 Dec. 2003, *P.J. Ainsley 62, M. Oborn, J. Currie, T.L. Durber & D. Taylor* (AD, K); Playford Rd, S side of rd res., 0.9 km E of Bomb Alley Rd, 18 Dec. 2018, *C. Clowes & M.W. Malcolm CC551* (AD, MELU); N side of Kingscote-American R. Rd, E of Ben Johnson's corner, 14 July 1984, *G. Jackson 1656* (AD); Junction of MacGillivray Hill & American R. rd, 29 Sep. 1984, *G. Jackson 1663* (AD, MSC); Willsons Rd, off Hog Bay Rd, W of Johnsons Corner, 13 Oct. 2009, *J. Kellermann 484, 485 & I.M. Kellermann Williams* (AD, BAA, MEL); Beyeria C.P., on walking tk, 13 Oct. 2009, *J. Kellermann 486, I.M. Kellermann Williams & K.L. Kellermann Williams* (AD); Near Sect. 194, Hundred of Haines, Hog Bay Rd, 16 June 1984, *B.[M.] Overton 33* (AD, BA); Hundred Line Rd, approx. 6 km S of racecourse bridge over Cygnet R., bottom of Kohinoor Hill, 17 Dec. 1993, *B.M. Overton 2405* (AD); Birchmore Rd, 5 km S of Playford Hwy, W roadside, 28 Apr. 2002, *B.M. Overton 2853* (AD); Ben Johnson's Corner, triangle of vegetation in NW corner of 5 ways intersection from Beyeria C.P., corner Hog Bay Rd, Willsons Rd, 27 Sep. 1995, *F. Udovicic 232* (AD, CANB, MEL, PERTH).

### 3. *Spyridium latifolium* Kellermann, *sp. nov.*

*A* Spyridio glabrisepalo *(J.M.Black) Kellermann foliis inflorescentibusque latioribus et sepalis hirsutis differt.*

**Holotypus:** Fire track on E side of Bullock Hill Conservation Park, c. 50 m from Haines Rd, on W side of track, 1.5 m tall shrub, spindly, 3 Feb. 2008, *J. Kellermann 455 & A. Kellermann* (AD213824). **Isotypi:** B, CANB, K, KUN, MEL, MO, NY, SI.

*Spyridium* sp. Finniss (*J.Kellermann 653 & F. Nge*) Kellermann in C.Clowes *at al.*, *Austral. Syst. Bot.* 35: 107 (2022).

*Shrubs* to 1.5 m high; young stems densely pubescent with white to rusty, loosely appressed to spreading, long simple over smaller stellate hairs. *Leaves* alternate: *stipules* triangular to broadly triangular, 1.2–3 mm long, fused for about half of their length, sometimes less, light brown to reddish-brown, glabrous or with hairs along midrib; *petiole* 0.4–1.3 mm long, glabrous; *lamina* narrowly elliptic to narrowly ovate or ovate, 6–12 mm long, 1–4.2 mm wide, base obtuse to cordate, margins recurved to slightly revolute, apex acute to bluntly

acute, ending in a dark mucro, upper surface glabrous, smooth to muricate or shortly hispid, lower surface visible or obscured by margins, with dense white stellate hairs, long appressed white simple hairs along midrib and leaf margins, a few along secondary veins. Densely felty *floral leaves* absent, inflorescence subtending leaves similar to vegetative leaves. *Inflorescence* a dense axillary or terminal head of up to 22 cymosely arranged ± sessile flowers, 3–9 (–11) mm diam., very resinous, esp. when young; inflorescence *axis* 1.5–7 (–14) mm long, densely pubescent with white stellate hairs and few simple hairs, sometimes rusty; *bracts* ovate, 1.2–2 mm long, mostly glabrous, margins ciliate. *Flowers* white. *Hypanthium tube* 0.3–0.5 mm long, 0.5–1.3 mm diam., with sparse long simple hairs over smaller stellate hairs, base similarly pubescent. *Sepals* 0.6–0.8 mm long with an indumentum of sparse simple over smaller stellate hairs, esp. in middle of sepal. *Petals* 0.4–0.5 mm long, cucullate, distinctly clawed; limb:claw ratio c. 3:1. *Stamens* subequal to the petals, c. 0.3 mm long; *anthers* 0.15–0.2 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube, which is notched adjacent to the stamens. *Ovary* inferior, carpels 3, summit with dense erect stellate and simple hairs; *style* 0.3–0.6 mm long, entire, slightly 3-lobed at apex. *Fruits* obovoid to ellipsoid, c. 2.3 mm long, c. 1.6 mm wide, consisting of 3 white papery fruitlets of which often only 1–2 develop fully, torus almost apical, fruit wall ± glabrous, dark brown; *seeds* flattened ovoid to ellipsoid, 1.3–1.4 mm long, 1–1.1 mm wide, fawn to light brown with dark mottles throughout, base dark. **Fig. 3.**

***Illustrations:*** N. Gemmell, *Native Veg. Strathalbyn Plains* 23 (1987); G.R.M. Dashorst & J.P. Jessop, *Pl. Adelaide Plains & Hills* 100, plate XLIII.8 (1990), as *Spyridium eriocephalum* (also subsequent editions; voucher: *D.E. Murfet s.n.*, AD).

***Distribution & habitat.*** This species occurs in the south-east of the Mt Lofty Ranges in the area between Strathalbyn, Goolwa and Victor Harbor, South Australia, in dense scrub and mallee woodland with a heathy understorey on sand and loamy sand (Fig. 7).

**Fig. 3.** *Spyridium latifolium* at Bullock Hill C.P., the type locality (A, C, D), and Winery Road Reserve (B), Fleurieu Peninsula, South Australia. **A** Habit; **B** flowering branches; **C** twig with older inflorescences; **D** close-up of flower-head. — B *J. Kellermann 661 & F. Nge*, D *JK 653 & FN*. Photos by J. Kellermann.

**Fig. 4. A** The controlled burn in part of Bullock Hill C.P., the type locality (3 Nov. 2020). **B** Seedling of *Spyridium latifolium* in the recently burned area (27 Aug. 2021). — B *J. Kellermann 1011 & L. Williams*. Photos by Department of Environment and Water (A) and J. Kellermann (B).

***Phenology.*** Flowers mainly in Aug.–Nov.

***Affinities.*** This species differs from *Spyridium eriocephalum* in its wider leaves (1–4.2 mm vs 0.3–1.1 (–1.6) mm in *S. eriocephalum*), which are narrowly elliptic to ovate in outline, with the lower surface being clearly visible (vs linear leaves, which are usually revolute, i.e. the margins obscuring most of the lower surface). *Spyridium glabrisepalum* differs in its smaller flower-heads, glabrous sepals and slightly narrower leaves (0.8–3 mm). The inflorescences of *S. latifolium* are also slightly larger, with a diameter of 2–9 (–11) mm (vs 3–7 mm in *S. eriocephalum* and 2.5–6.5 mm in *S. glabrisepalum*).

***Conservation status.*** The conservation status of this species should be assessed. It is conserved in Bullock Hill C.P. and Scott Creek C.P. and also grows in old railway reserves.

***Notes.*** The species seems to be quite short-lived and to rely on bushfires for regeneration, similar to some other species of *Spyridium*. When the type specimen was collected in 2008, *S. latifolium* was very frequent in Bullock Hill C.P. (*J. Kellermann 455 & A. Kellermann*), but ten years later, hardly any plants remained at the type locality (*J. Kellermann 653 & F. Nge*). In Aug. 2021, about 9 months after a controlled burn in Nov. 2020, an abundance of seedlings was observed in the recently burned area (*J. Kellermann 1011 & L. Williams*). The seedlings differ in morphology from adult plants, i.e. stipules are inconspicuous and the indumentum on most parts of the plants is almost absent. Where present, the indumentum consists of the typical stellate hairs of Pomaderreae. While the leaves are quite wide, they are of the correct shape and have the characteristic recurved margins (Fig. 4).

***Etymology.*** From the Latin *latis* (wide) and *folium* (leaf) on account of the species' distinctive leaves that are much wider than typical *Spyridium eriocephalum*.

***Selected specimens examined*** (c. 85 seen)

SOUTH AUSTRALIA. 2 miles [3.2 km] N of Goolwa, 15 Nov. 1943, *H.M. Cooper s.n.* (AD); Finniss Oval Res., 7 Sep. 2007, *D.J. Duval 831* (AD); Finniss Oval Res., 25 Nov. 2010, *D.J. Duval 2055* (AD, MEL); Bullock Hill C.P., SE corner, c. 10 m N of Haines Rd, 3 Feb. 2008, *J. Kellermann 448 & A. Kellermann* (AD, BM, MEL, P, W); Fire tk on E side of Bullock Hill C.P., c. 50 m from Haines Rd on W side of tk, 1.5 m tall shrub, spindly, 3 Feb. 2008, *J. Kellermann 456 & A. Kellermann* (AD, M); Bullock Hill C.P., along tk in middle of park, 14 Oct. 2018, *J. Kellermann 653 & F. Nge* (AD, CANB); Res. between Winery Rd and railway tk, Currency Creek, near access gate, 14 Oct. 2018, *J. Kellermann 661 & F. Nge* (AD, KUN, SI); Bullock Hill C.P., E of fire tk in middle of park, 27 Aug. 2021, *J. Kellermann 1011 & L. Williams* (AD, seedlings); Currency Creek railway, 3 Feb. 1989, *D.E. Murfet s.n.* (AD); Scott Creek C.P., 28 Feb. 2000, *A.C. Robinson & S.J. Pillman BS117-1526* (AD); On W verge of Echo Park Rd, between Nine Mile Rd intersection and Finniss-Milang Rd, Milang, 26 Oct. 2000, *R. Taylor 570* (AD).

### 4. *Spyridium undulifolium* Kellermann & S.A.J.Bell, *sp. nov.*

*A* Spyridio eriocephalo *Fenzl foliis junioribus undulatis et plerumque linearibus, apicibus rectis et floribus hypanthio longiore differt.*

**Holotypus:** Adjacent Wollar-Mudgee Rd, Wollar, near railway tunnel and opposite 'Cortina' property, 19 Nov. 2015, *S. Bell & C. Driscoll s.n.* [*1*] (NSW). **Isotypi:** AD272766, B, CANB, K, MEL, NY, SI.

*Spyridium* sp. Wollar (*E.F.Constable s.n.*, NSW16590) Kellermann in C.Clowes *et al.*, *Austral. Syst. Bot.* 35: 107 (2022).

*Shrubs* to 0.5 m high; young stems pubescent with medium to dense white to rusty appressed long simple hairs over smaller stellate hairs. *Leaves* alternate: *stipules* narrowly triangular to triangular, 2.2–5 mm long, almost entirely fused, reddish-brown, glabrous, but with hairs along midrib and ciliate towards apex; *petiole* 0.5–1.2 mm long, glabrous; *lamina* linear to very narrowly elliptic, 6.8–12 mm long, 0.5–1.1 mm wide, when young wavy or curved, base narrowly cuneate to cuneate, margins strongly recurved to revolute, acuminate, ending in a long brown drawn-out tip, upper surface appearing glabrous but usually minutely muricate to shortly hispid, lower surface mainly obscured by margins, with dense white stellate hairs, midrib also with long appressed white simple hairs. Densely felty *floral leaves* absent, inflorescence subtending leaves similar to vegetative leaves. *Inflorescence* a dense axillary or terminal head of up to 20 cymosely arranged ± sessile flowers, 7–14 mm diam.; inflorescence *axis* (3.5–) 7–13 mm long, densely pubescent with white stellate and simple hairs; *bracts* ovate, c. 3 mm long, mostly glabrous, simple hairs along middle, margins ciliate. *Flowers* white. *Hypanthium tube* 1–1.2 mm long, 1.3–1.6 mm diam., with sparse long white simple hairs, base similarly pubescent. *Sepals* 0.7–1.3 mm long, with an indumentum of medium dense to dense white simple and stellate hairs. *Petals* 0.5–0.6 mm long, cucullate, distinctly clawed; limb:claw ratio c. 4:1. *Stamens* subequal to the petals, 0.5–0.6 mm long; *anthers* 0.15–0.2 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube, which is distinctly notched adjacent to the stamens (almost appearing as separate lobes). *Ovary* inferior, carpels 3, summit with dense erect stellate and simple hairs; *style* 0.8–1 mm long, entire, slightly 3-lobed at apex. *Fruits* obovoid to ovoid, c. 2.8 mm long, c. 1.6 mm wide, consisting of 3 white papery fruitlets of which often only 2 develop fully, torus almost apical, fruit wall ± glabrous, dark brown to black; *seeds* flattened obovoid to ellipsoid, c. 1.9 mm long, c. 1.2 mm wide, fawn to light brown with only a few dark mottles present, base dark brown. **Fig. 5.**

**Fig. 5.** *Spyridium undulifolium* at the type locality, a rocky hillside above Wollar Road, New South Wales. **A** Plants growing below spinifex (*Triodia scariosa*); **B** habit when growing in the open; **C** plant growing in and protected by spinifex; **D** flower-head and new growth with wavy young leaves; **E** close-up of flower-head. — Photos by S.A.J. Bell.

***Distribution & habitat.*** The species is known only from two adjacent north-facing dry hills near Wollar, New South Wales, in low stunted open woodland of *Eucalyptus punctata*, *E. albens* and *Allocasuarina verticillata*, amongst *Triodia scariosa*, *Xanthorrhoea glauca*, *Hibbertia cistoidea* and *Acacia ixiophylla* on skeletal soil (yellow brown sand) over shale (Fig. 7). This hill is distinctive within the wider locality due to the poor canopy development across landscapes that otherwise support well developed open forests and woodlands. The dominance of *Triodia scariosa* in particular is very rare in the region.

***Phenology.*** Flowering specimens have been collected in July, Sep., Nov. and Dec.

***Affinities.*** The species differs from *Spyridium eriocephalum* in its long linear revolute leaves that are slightly wavy when young (Fig. 5D) and have a straight apex (vs distinctly recurved apex in *S. eriocephalum*). The inflorescences of the new species are larger (7–14 mm vs 3–7 mm diameter); the hypanthium tube and sepals are also much longer (1–1.2 mm and 0.7–1.3 mm vs 0.3–0.8 mm and 0.5–1 mm in *S. eriocephalum*, respectively) and the seed surface is light brown with only few dark mottles (vs densely mottled). *Spyridium glabrisepalum* and *S. latifolium* can easily be distinguished by their much broader leaves.

***Conservation status.*** Only a single population extending across two adjacent low hills is currently known, largely on Crown land, but also on adjacent private property. No threats are apparent at this stage; however, existing and proposed new open cut coal mines are a feature of the wider locality (DPIE 2020b).

***Notes.*** Extensive field surveys carried out for several vegetation mapping projects across private lands between Bylong and Ulan, and in the nearby Goulburn River N.P. and Wollemi N.P., have failed to uncover other populations or habitats similar to the type location. Soils at the Wollar site have been mapped as part of the 'Benjang variant b' colluvial soils landscape by DPIE (2020a), which comprises undifferentiated sediments of the Singleton Coal Measures and occurs extensively in nearby Wollemi N.P. and Munghorn Gap N.R. Further inspection of these landscapes elsewhere may uncover new populations of *Spyridium undulifolium*, and such areas should be the focus for targeted surveys.

***Etymology.*** The specific epithet is a contraction of the Latin *undulatus* (wavy) and *folius* (leaf), in reference to the distinctly wavy young leaves.

***Specimens examined***

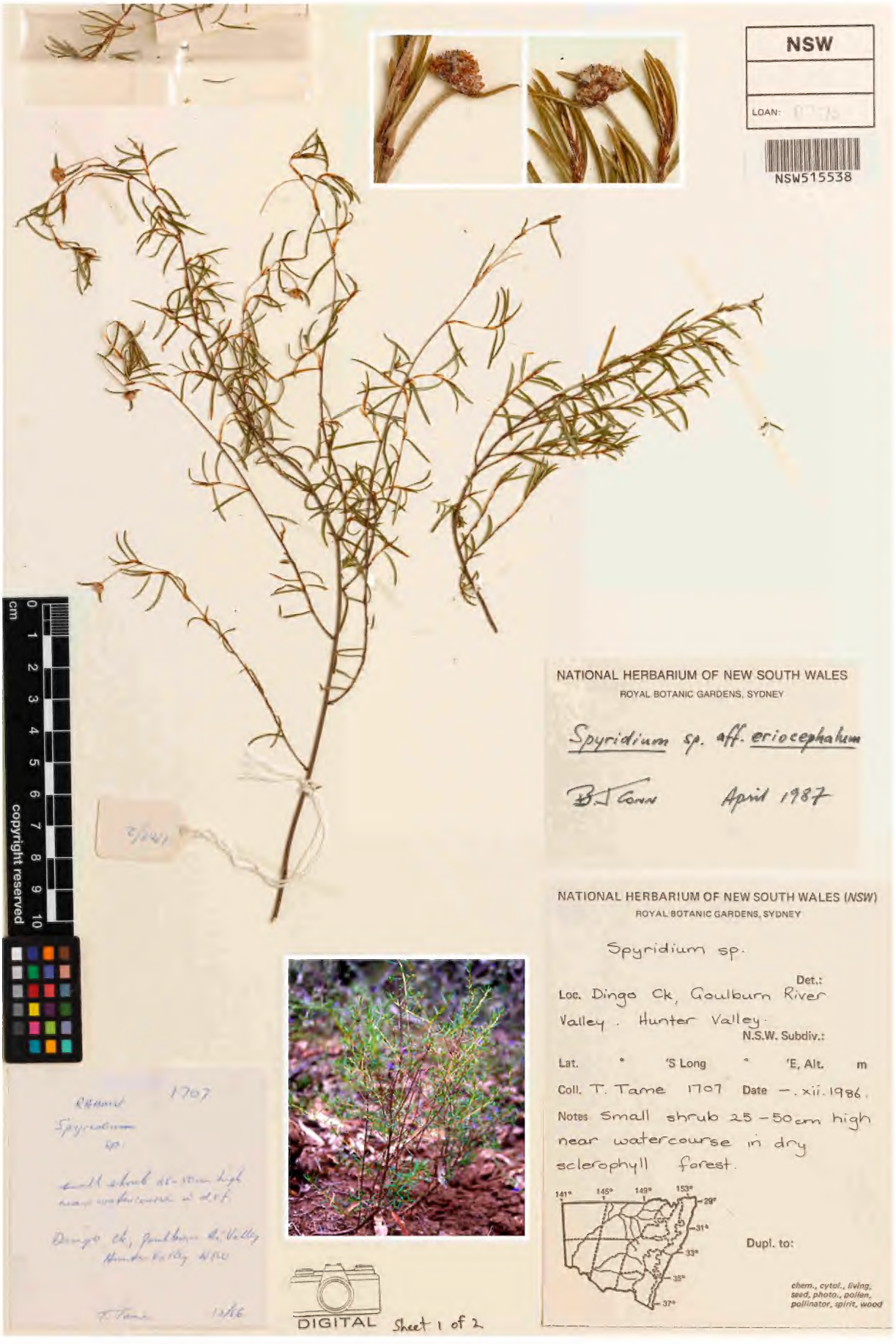
NEW SOUTH WALES. Adjacent Wollar-Mudgee Rd, Wollar, near railway tunnel and opposite 'Cortina' property, 19 Nov. 2015, *S. Bell & C. Driscoll s.n.* [*2*] (AD, DMHN, NE, NSW); 20 Dec. 2016, *S. Bell & C. Driscoll s.n.* [*CC566*] (CANB, DMHN, MEL, MELU); Wollar, Sandy Hollow, 16 Sep. 1948, *E.F. Constable s.n.* (MEL, NSW); Near Wollar, S of Merriwa, 19 July 2001, *T. Peake HT1885* (NSW); Near Wollar, S of Merriwa, 15 Sep. 2003, *T. Peake HT1924* (NSW); S of Wollar-Muswellbrook rd, 17 July 2003, *H. Washington s.n.* (NSW).

### 5. *Spyridium* sp. Dingo Creek (*T. Tame 1011*) Kellermann

*Shrubs* to 0.5 m high; young stems pubescent with medium dense appressed white long simple hairs over sparse smaller stellate hairs. *Leaves* alternate: *stipules* narrowly triangular to linear filiform, 2.5–4.6 mm long, almost entirely fused, reddish-brown, glabrous; *petiole* 0.7–1 mm long, glabrous; *lamina* linear to very narrowly elliptic, 10–15 (–20) mm long, 0.6–1 mm wide, base narrowly cuneate to cuneate, margins strongly recurved to revolute, acute to acuminate, upper surface glabrous to very shortly hispid, lower surface mainly obscured by margins, with dense white stellate hairs, midrib also with long appressed white simple hairs. Densely felty *floral leaves* absent, inflorescence subtending leaves similar to vegetative leaves. *Inflorescence* a dense axillary or terminal head of up to 15 cymosely arranged ± sessile flowers, 4–6 mm diam.; inflorescence *axis* 10–18 mm long, with appressed long white simple hairs; *bracts* ovate, c. 2.2 mm long, mostly glabrous, simple hairs along middle, margins ciliate. *Flowers* white. *Hypanthium tube* c. 1.1 mm long, c. 0.6 mm diam., with sparse white simple hairs, base with similar hairs or almost glabrous. *Sepals* c. 0.6 mm long, with an indumentum of medium dense white simple over sparse stellate hairs. *Petals* 0.4–0.5 mm long, cucullate, distinctly clawed; limb:claw ratio c. 4:1. *Stamens* subequal to the petals, c. 0.4 mm long; *anthers* c. 0.15 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube. *Ovary* inferior, carpels 3, summit with dense erect stellate and simple hairs; *style* c. 0.9 mm long, entire, slightly 3-lobed at apex. *Fruits* obovoid to ellipsoid, 1.5–1.9 mm long, 1.25–1.5 mm wide, containing 3 white papery fruitlets of which often only 2 develop fully, torus in upper third, fruit wall mainly glabrous with a few simple hairs, dark brown to black; *seeds* flattened ovoid to ellipsoid, 1.1–1.6 mm long, 0.8–1.2 mm wide, fawn to light brown with some dark mottles, base dark brown. **Fig. 6.**

***Notes.*** This entity is given a phrase name here, as it is based only on three specimens, collected in the 1980s from Dingo Creek in the Goulburn River valley, between Widden and Baerami (Fig. 7). The precise location is not known and a recent search (Dec. 2021) of part of this creek system failed to locate the population. Apart from a fire encroaching on the western side of the creek in 2006, the area has not been burnt for many years, i.e. it is possible the taxon now remains only in the seed bank. Further searches post-fire are recommended.

Flowering and fruiting characters are based on measurements of only one flower (*T. Tame 1381*) and two fruits (*T. Tame 1011*).


NSW
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NATIONAL HERBARIUM OF NEW SOUTH WALES
ROYAL BOTANIC GARDENS, SYDNEY
Spyridium sp. aff. eriocephalum
B.J. Conn April 1987
NATIONAL HERBARIUM OF NEW SOUTH WALES (NSW)
ROYAL BOTANIC GARDENS, SYDNEY
Spyridium sp.
Det.:
Loc. Dingo Ck, Goulburn River Valley. Hunter Valley.
N.S.W. Subdiv.:
Lat. ° 'S Long ° 'E, Alt. m
Coll. T. Tame 1707 Date –.xii.1986.
Notes Small shrub 25–50cm high near watercourse in dry sclerophyll forest.
Dupl. to:
chem., cytol., living, seed, photo., pollen, pollinator, spirit, wood
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Sheet 1 of 2

**Fig. 6.** *Spyridium* sp. Dingo Creek (*T. Tame 1011*). Herbarium specimen (*T. Tame 1707*), showing the very lax branches with long narrow leaves. Top insets: close-up of two flower-heads (*T. Tame 1011*). Bottom inset: photo from collecting locality by the collector of the specimen (T.M. Tame; courtesy Royal Botanic Gardens and Domain Trust, Sydney).

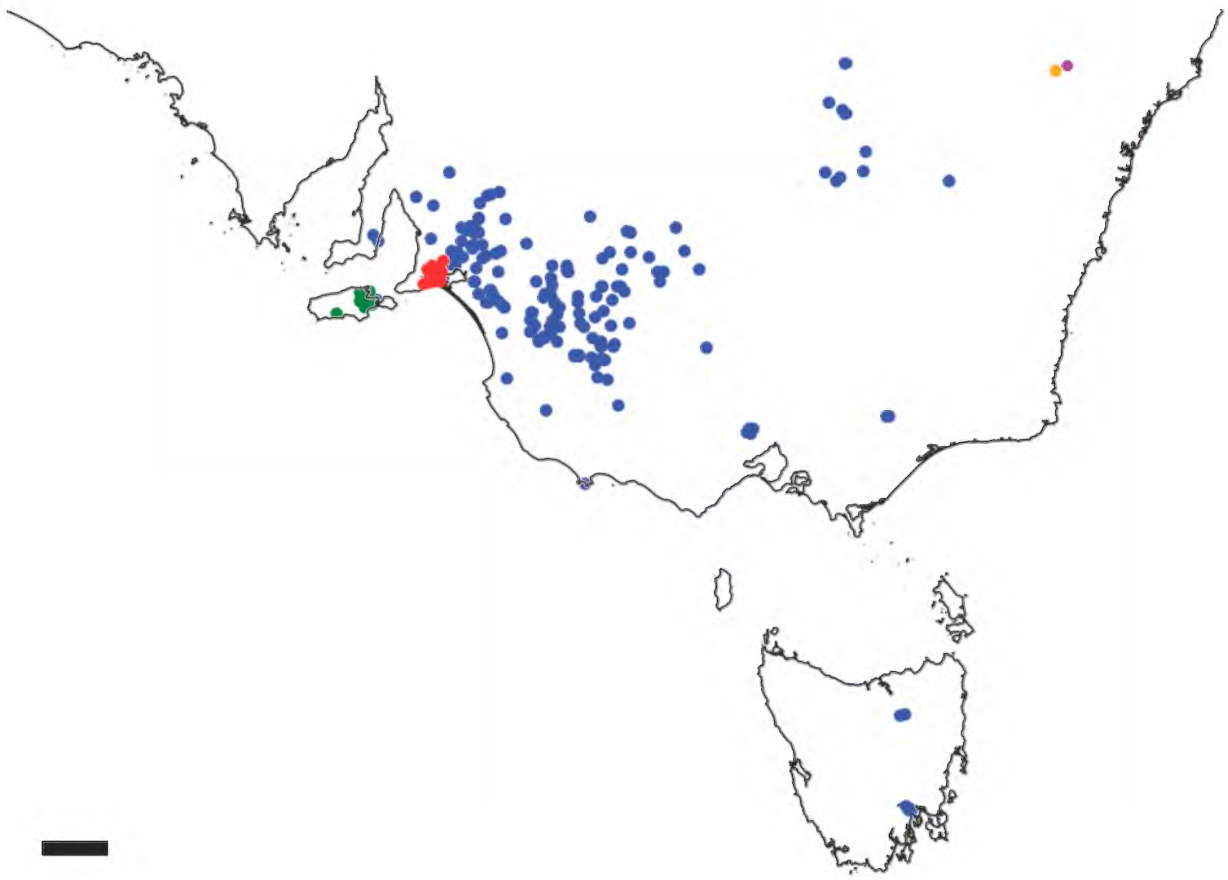

**Fig. 7.** Distribution map of taxa in the *Spyridium eriocephalum* complex, created from specimens examined: *S. eriocephalum* (blue), *S. glabrisepalum* (green), *S. latifolium* (red), *S. undulifolium* (orange) and *Spyridium* sp. Dingo Creek (purple). Scale bar = 100 km.

***Habitat.*** All three specimens were presumably collected at the same locality but in different years, "[N]ear watercourse in dry sclerophyll forest" (*T. Tame 1707*) in "[S]andy alluvial soil" (*T. Tame 1011*). On the third specimen the collecting locality is described as: "Shrubland on creek bank. In damp, well drained, semi-shaded site on creek bank. Loose sandy soil." (*T. Tame 1381*). Recent observations along the creek found the vegetation to comprise an overstorey of *Eucalyptus punctata*, *Acacia linearifolia* and *Eucalyptus crebra*, with a dense understorey of *Bursaria spinosa*, *Cassinia quinquefaria*, *Acacia caesiella*, *Isopogon dawsonii*, *Leptospermum* spp., *Notelaea microcarpa*, *Cyphanthera albicans* and *Spyridium buxifolium*.

***Phenology.*** Flowering between Aug. and Dec.; the single fruiting specimen was collected in Nov.

***Affinities.*** *Spyridium* sp. Dingo Creek might be a form of *S. undulifolium*, which occurs c. 50 km to the west, but it can be distinguished from that species by its longer and narrower leaves, and much smaller flower-heads with a longer inflorescence axis. There are also marked habitat differences between these two locations: *Spyridium* sp. Dingo Creek occurring in alluvium along a creekline, while *S. undulifolium* occurs on an exposed hill with skeletal shale soils. However, close proximity to a stream in a moist habitat may produce plants of a different habit, compared to typical *S. undulifolium*, but this requires further investigation. The phrase name taxon might also be a form of the widespread and more variable *S. eriocephalum*, from which it differs in the thinner leaves, lax habit and dense simple hairs on young branches, but the closest known populations of *S. eriocephalum* are 350–400 km away.

In the molecular analysis of Clowes *et al.* (2022), only *S. undulifolium* was included, not *Spyridium* sp. Dingo Creek. It is therefore necessary to re-locate the population of this entity and include it in future research on the *S. eriocephalum* complex to identify its most appropriate taxonomic position.

### *Specimens examined*

NEW SOUTH WALES. Dingo Creek, Goulburn R. Valley, Hunter Valley, 1 Aug. 1984, *T. Tame 1011* (NSW); 10 Nov. 1985, *T. Tame 1381* (AD, NSW); 1 Dec. 1986, *T. Tame 1707* (NSW).

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Bauer. Kat Ticli (AD) is thanked for scoring the vegetative characters of the species and for taking images of herbarium specimens. We appreciate comments on the manuscript by Mark Wapstra and an anonymous referee. The project "A new phylogeny of the Australian Rhamnaceae, revision of *Cryptandra* and *Spyridium*, and completion of the *Flora of Australia* treatment of the family" is supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) National Taxonomy Research Grant Programme. Catherine Clowes was supported by a Holsworth Wildlife Research Endowment (The Ecological Society of Australia), and the Hansjörg Eichler Scientific Research Fund (Australasian Systematic Botany Society).

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# *Spyridium bracteatum*, a new species from Kangaroo Island allied to *S. thymifolium* (Rhamnaceae: Pomaderreae)

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**Abstract:** *Spyridium thymifolium* Reissek and the new species *S. bracteatum* Kellermann & W.R.Barker are described and illustrated. The former species occurs on both Kangaroo Island and the adjacent Fleurieu Peninsula, South Australia; the new taxon is endemic to Kangaroo Island. Both species exhibit distinctly 'tiled' bracts in fruiting inflorescences. A lectotype is chosen for *S. thymifolium*.

**Keywords:** New species, typification, Rhamnaceae, *Spyridium*, South Australia

## Introduction

*Spyridium* Fenzl is a genus of c. 45 species, mainly occurring in southern regions of Australia. It is one of the larger genera of Rhamnaceae in Australia and placed in the tribe Pomaderreae (Richardson *et al.* 2000; Medan & Schirarend 2004). There are around 12 taxa of *Spyridium* present on Kangaroo Island (KI); together with Eyre Peninsula (EP), where at least 15 taxa are present (State Herbarium of South Australia 2021), and south-western Western Australia (18 taxa; Western Australian Herbarium 1998-), KI is one of the centres of diversity of the genus.

For over 30 years, an entity was known from KI that did not fit any currently recognised taxa. Herbarium specimens were variously identified as *Spyridium thymifolium* Reissek, *S. vexilliferum* (Hook.) Reissek, *S. bifidum* var. *integrifolium* J.M.Black (a synonym of *S. bifidum* subsp. *wanillae* Kellermann & W.R.Barker from EP, but the name has also been misapplied to other taxa), or the specimens were given names of species that are not even present in South Australia, e.g. the Tasmanian species *S. obovatum* (Hook.) Benth.

A recent molecular phylogeny of all currently recognised species of *Spyridium* (Clowes *et al.* 2022) also included several samples of that entity, under the phrase name *Spyridium* sp. Kangaroo Island (*W.R. Barker 7560*) Kellermann. The results clearly separated the taxon from *S. thymifolium* and the other taxa mentioned above. In line with this new evidence, it is here described as a new species, *Spyridium bracteatum* Kellermann & W.R.Barker.

Characteristic of the new species is the presence of conspicuous 'tiled' bracts in the older inflorescence. These were first described and illustrated by Kellermann & Barker (2007, Fig. 1q): as fruits develop in the flower-head, it expands by 2–3 times its size, presumably to accommodate the enlarging ovaries in the developing fruits and to facilitate the release of the ripe fruitlets (the disseminules in *Spyridium*); the bracts in these enlarged heads appear in a typical 'roof-tile' pattern. While this phenomenon is not limited to the new taxon, it is most noticeable and striking in these plants. Other species with tiled bracts are, for example, *Spyridium coactilifolium* Reissek, *S. scabridum* (Tate) Kellermann & W.R.Barker (both described in Kellermann & Barker 2007) and *S. thymifolium* (described below).

## Taxonomy

### 1. *Spyridium bracteatum* Kellermann & W.R.Barker, *sp. nov.*

*A* Spyridio thymifolio *Reissek stipulis conjunctis et foliis angustioribus differt.*

**Holotypus:** South Australia, Kangaroo Island, Playford Hwy, c. 3 km by road WNW of Shackle Road turnoff, 14 km direct ESE of Cape Borda, alt. 240–250 m, 6 Oct. 1982, *W.R. Barker 4487* (AD98248005). **Isotypi:** B, CANB, MEL2334938, NY.

*Spyridium* sp. Kangaroo Island (*W.R.Barker 7560*) Kellermann in C.Clowes *et al.*, *Austral. Syst. Bot.* 35: 107 (2022).

*Spyridium bifidum* var. *integrifolium auct. non* J.M.Black: E.M.Canning in Jessop & Toelken, *Fl. S. Austral.* 2: 817 (1986).


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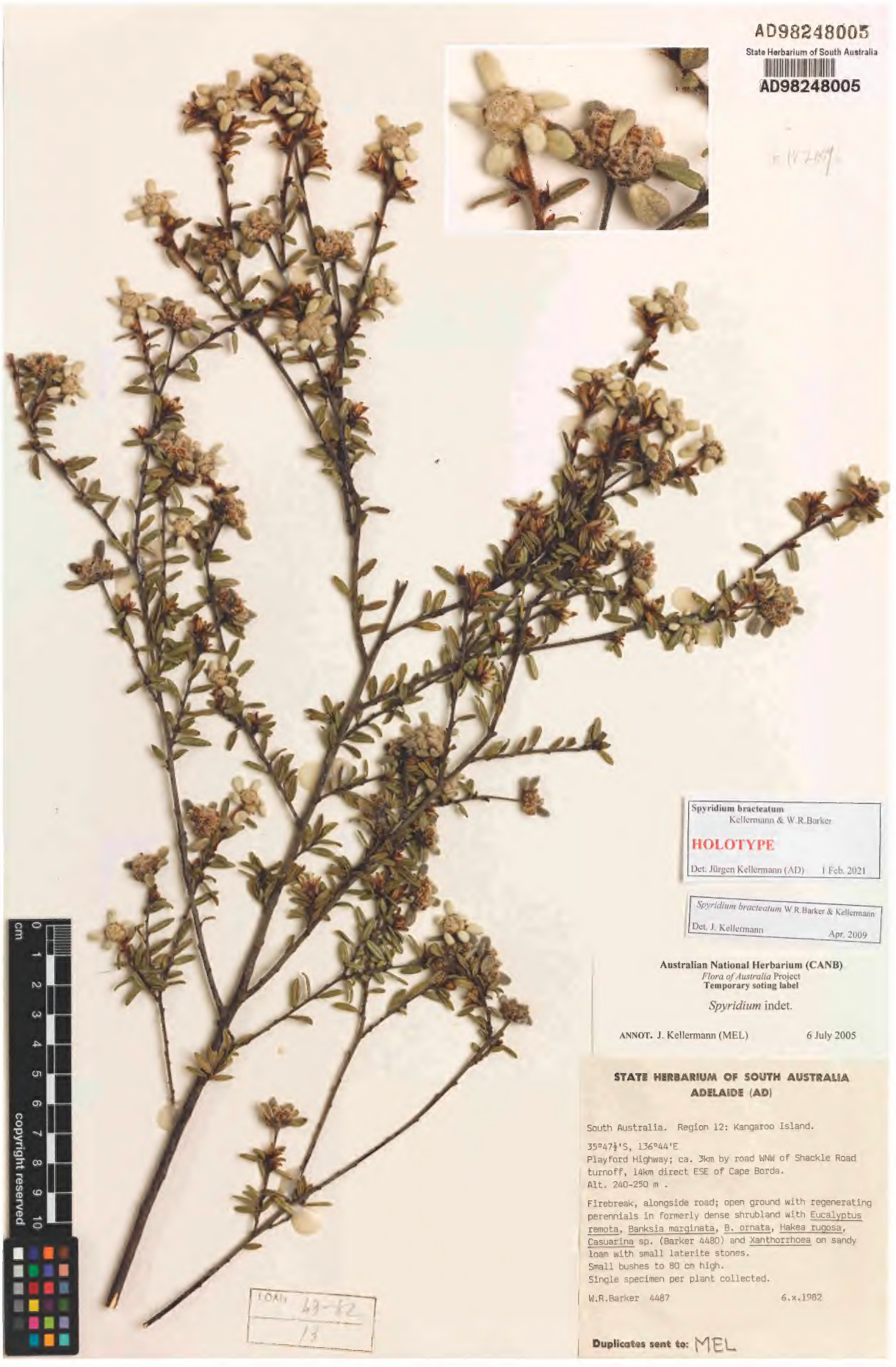
AD98248005
State Herbarium of South Australia
AD98248005
Spyridium bracteatum
Kellermann & W.R.Barker
HOLOTYPE
Det. Jürgen Kellermann (AD) 1 Feb. 2021
Spyridium bracteatum W.R.Barker & Kellermann
Det. J. Kellermann Apr. 2009
Australian National Herbarium (CANB)
Flora of Australia Project
Temporary soting label
Spyridium indet.
ANNOT. J. Kellermann (MEL) 6 July 2005
STATE HERBARIUM OF SOUTH AUSTRALIA
ADELAIDE (AD)
South Australia. Region 12: Kangaroo Island.
35°47½'S, 136°44'E
Playford Highway; ca. 3km by road WNW of Shackle Road turnoff, 14km direct ESE of Cape Borda.
Alt. 240-250 m .
Firebreak, alongside road; open ground with regenerating perennials in formerly dense shrubland with Eucalyptus remota, Banksia marginata, B. ornata, Hakea rugosa, Casuarina sp. (Barker 4480) and Xanthorrhoea on sandy loam with small laterite stones.
Small bushes to 80 cm high.
Single specimen per plant collected.
W.R.Barker 4487 6.x.1982
Duplicates sent to: MEL
cm
copyright reserved

**Fig. 1.** *Spyridium bracteatum*, holotype, *W.R. Barker 4487* (AD98248005). Inset: close-up of two flower-heads, a younger one on the left, surrounded by felty floral leaves, and an older inflorescence with 'tiled' bracts on the right.

**Fig. 2.** *Spyridium bracteatum*. **A** Flower-head with densely felty floral leaves; **B** close-up of vegetative leaf on a young branch. — *C. Clowes CC556 & M.W. Malcolm*. Photos by C. Clowes.

*Shrubs* to 1.8 (–2) m high; young stems densely pubescent with rusty, spreading, long simple and stellate hairs, becoming ± matted and white or grey when older. *Leaves* alternate: *stipules* ovate, triangular to narrowly triangular, 1.1–3.7 (–4) mm long, fused for one quarter to half of their length (rarely abutting), reddish-brown, glabrous, with hairs along midrib and ciliate towards apex; *petiole* (1.1–) 1.8–2.6 (–4.3) mm long, stellate pubescent, becoming glabrous and papillose when old; *lamina* narrowly ovate to narrowly obovate to narrowly elliptic to oblong (broader in young plants), 6–17.6 mm long, 1.5–3.7 (–7) mm wide, base obtuse to cuneate, margins recurved, rarely revolute, apex obtuse or acute to bluntly acuminate, upper surface glabrous or occasionally with scattered long hairs, with only the midrib (often deeply) impressed, lower surface with a dense indumentum of white, ± matted flexuose stellate hairs, becoming grey when older, midrib also with long simple hairs, rusty when young, becoming white. *Floral leaves* usually 3–5 (–6): broader and sometimes rounder than stem-leaves, (4–) 4.5–9.5 mm long, 2–4.8 (–5.5) mm wide, covered with very dense, white, felty, stellate indumentum, becoming grey when old. *Inflorescence* a dense axillary head of more than 20 cymosely arranged ± sessile flowers, 5–8 mm diameter; inflorescence *axis* 11–25 mm long, densely pubescent with rusty and white hairs; *bracts* broadly ovate, 2–3.5 mm long, outside mostly glabrous, with dense long cilia. *Flowers* white to cream. *Hypanthium*: free tube 0.5–0.7 mm long, 0.6–0.8 (–1.2) mm diameter, with a moderately dense indumentum of long simple hairs; base similarly pubescent. *Sepals* 0.4–0.7 (–1) mm long, with dense, erect, simple and stellate hairs, especially towards the tip. *Petals* (0.3–) 0.4–0.6 mm long, cucullate, distinctly clawed; limb:claw ratio c. 2:1. *Stamens* subequal to the petals, 0.3–0.4 mm long; *anthers* 0.15–0.2 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube (or slightly below). *Ovary* inferior, carpels 3, summit with dense, erect stellate hairs; *style* (0.3–) 0.4–0.6 mm long, entire, slightly 3-lobed at apex. *Infructescence* conspicuously expanding in fruit, so 'tiled' bracts are visible. *Fruits* obovoid to ellipsoid, c. 1.3–1.5 (–2) mm long, 0.8–0.9 (–1.5) mm wide, consisting of 3 white papery fruitlets of which usually only 1 or 2 develop fully, torus in upper third to apical, fruit wall ± glabrous, dark brown; *seeds* flattened, obovoid to ellipsoid, c. 1.1–1.5 mm long, 0.7–1.1 mm wide, reddish brown with a darkened base. **Figs 1 & 2.**

***Distribution & habitat.*** The species is endemic to KI, where it mainly occurs in the north-western part of the

**Key to *Spyridium bracteatum* and morphologically similar species from Kangaroo Island**

**1.** Stipules free, overlapping behind petiole (if abutting then leaves with hairs on the upper surface)
- **2.** Leaves broad: ovate, elliptic, or orbicular . . . . . 2. ***S. thymifolium***
- **2:** Leaves narrow: oblong, narrowly ovate to narrowly obovate, or narrowly elliptic
  - **3.** Upper leaf surface villous to scabrous, with long simple hairs . . . . . ***S. scabridum***
  - **3:** Upper surface glabrous, sometimes with a few antrorse simple hairs along the margins . . . . ***S. vexilliferum***

**1:** Stipules fused for up to half of their length (if abutting then upper leaf surface glabrous)
- **4.** Upper leaf surface glabrous, sometimes with a few scattered hairs . . . . . 1. ***S. bracteatum***
- **4:** Upper surface covered with stellate hairs, sometimes simple or bifid hairs also present . . . . . ***S. coalitum***

island (Fig. 5). It grows in *Eucalyptus remota* woodland, *Eucalyptus obliqua-E. baxteri* stringybark woodland and dense shrublands or heathlands with a taller overstorey, on sandy loam and sand with laterite; some collecting notes indicate that it prefers damp habitats and waterlogged soils.

The bushfires in 2019/20 burned most of the known habitat of *Spyridium bracteatum* (Fig. 5). Post-fire vegetation surveys on KI in May 2021 also made one collection with seedlings (*Lang et al. SHSA-560*) from Flinders Chase National Park (N.P.). Further surveys are required to examine the regeneration of the taxon, but the closely related *S. thymifolium* tends to regrow from seed in large numbers after bushfires (e.g. after the 2006 fire in Cox Scrub Conservation Park; pers. obs.).

***Phenology.*** Flowering in Nov.–Feb. and Apr.; fruits recorded in Aug., Oct.–Feb.

***Affinities.*** *Spyridium thymifolium* can be distinguished from *S. bracteatum* by its ovate-elliptic to orbicular leaves, which are usually larger and with ± flat to recurved margins, longer petioles, and larger, free, but overlapping stipules. Compared to *S. thymifolium*, the flower heads are usually larger and the number of floral leaves is greater in *S. bracteatum*.

*Spyridium bracteatum* is also similar to *S. coalitum*, which differs in its smaller leaves with a slightly recurved and notched tip and the presence of stellate (rarely simple) hairs on their upper surface. A few specimens appear to be hybrids between *S. bracteatum* and *S. coalitum* (e.g. Borda Rd, 3 km E of Harveys Return, 11 Nov. 1994, *B.M. Overton 2499*, AD99610155). The large inflorescences in *Spyridium bracteatum* with c. 5 floral leaves are similar to those of *S. bifidum* subsp. *wanillae*, but that taxon occurs on Eyre Peninsula and has long simple hairs on the upper surface of the leaves.

***Notes.*** The stipules of the new species are usually fused for about half of their length. A few specimens display stipules that are abutting, but not fully fused. Abutting free stipules can also be found in *S. scabridum*, but that species is easily distinguished by the presence of long, simple hairs on the upper surface of the leaf.

The new species typically has leaves with a glabrous upper surface and a deeply impressed midvein, but no secondary veins are visible (or only faintly so); the indumentum on the lower surface consists of dense, white, matted hairs that become dirty grey, when older; hairs on the floral leaves often also turn grey in older inflorescences.

A fruit from one specimen examined (*J. Kellermann 510 & I.M. Kellermann Williams*) contained two dissimilar seeds, the first of which was reddish brown (as described above), the second seed was light coloured with dark mottling, similar to *S. thymifolium* (below).

***Etymology.*** The epithet is Latin and refers to the bracts of the inflorescence, which are very conspicuous once the flower-head expands during fruiting.

***Selected specimens examined*** (c. 100 seen)

SOUTH AUSTRALIA. **Kangaroo Island.** Western River headwaters, Watter's mail box, on E-W road, 3.2 km direct E of turnoff from Western River Cove Rd, c. 4.5 km direct NE of junction of Playford and West End Hwys, 7 Oct. 1982, *W.R. Barker 4489* (AD, BM, KW, MEL, MPU, NE, US); c. 10.5 km by road NNW of Karatta along Church Rd, c. 1.5 km by road NW of Baxters Rd turnoff, 8 Oct. 1982, *W.R. Barker 4520* (AD, NSW, K); c. 24 km E of Jump Off Rd to Cape Torrens on Playford Hwy, 29 Sep. 1995, *W.R. Barker 7560* (AD, CANB, MEL, MO, SI); 8.6 km E of Jump Off Rd, 29 Sep. 1995, *W.R. Barker 7561 & F. Udovicic* (AD ×2, CHR, G, GH, HBG, KUN, L, M, MEL, P, W; population collection); Playford Hwy, road reserve, S side of road, 28 Dec. 2018, *C. Clowes CC556 & M.W. Malcolm* (AD, MELU); 7 km E of Cape Borda by road along Playford Hwy, 12 Apr. 1973, *L. Haegi 408* (AD); West End Hwy intersection with Church Rd, Flinders Chase N.P., W side, 15 Oct. 2009, *J. Kellermann 510 & I.M. Kellermann Williams* (AD, B, BAA, CANB, MEL); Playford Hwy, *J. Kellermann 518* (AD, CANB, MEL); 3 km direct W of Rocky River Visitor Centre, Flinders Chase N.P., 9 May 2021, *P.J. Lang, T.M. Spokes & E. Biffin SHSA-560* (AD, seedlings); Roadside vegetation at Graingers Lagoon property, on Church Rd, 1.5 km E of Brookland Park, 30 Sep. 1995, *F. Udovicic 254* (AD, E, MEL, PERTH).

## 2. *Spyridium thymifolium* Reissek

*Linnaea* 29: 289 (1858). — *Spyridium coactilifolium* var. *integrifolium* Benth., *Fl. Austral.* 1: 431 (1863). — **Type citation:** "Encounter Bay Nov. 1847 (Dr. F. Müller)". **Lectotype (here designated):** Encounter, Austral. Austr., Nov. 1847, [*C. Stuart s.n.*] (W0015421, attributed to "F. Müller"). **Isolectotypes:** Encounter Bay, Nov. 1849 [*sic, 1847*], *C. Stuart s.n.* (MEL 2104786, labelled as "Trymalium (Pomaderris?) Stuartii Ferd.Mll. pro parte"). **Possible isolectotype:** Encounter Bay, S. Australia, *s.dat.*, *Anon. s.n.* (K000618737, ex Herb. Hooker, with detailed drawing of flower, labelled as "Pomaderris / Trymalium stuarti F.Müller" and as "Spyridium coactilifolium Reiss. var. integrifolium").

*Spyridium stuartii* Reissek & F.Muell., *Linnaea* 29: 289 (1858), as "*stuarti*". — **Type citation:** "Encounter Bay Nov. 1847 (Dr. F. Müller)". **Lectotype:** Encounter Bay, Nov. 1847, [*C. Stuart s.n.*] (MEL 2104271, labelled as "Spyridium stuartii Reiss. & Muell."), *fide* Kellermann & W.R.Barker, *Muelleria* 30: 56 (2012). **Isolectotypes:** Encounter Bay, *s.dat.*, *C. Stuart s.n.* (MEL 2104272A, top specimen, labelled as "Spyridium Stuartii F. Muell."); Encounter Bay, Nov. 1847, [*C. Stuart s.n.*] (W0015422, attributed to "F. Müller").

*Trymalium stuarti* F.Muell. ex Reissek, *Linnaea* 29: 289 (1858), *nom. inval. pro syn.* (listed by Reissek under both, *S. thymifolium* and *S. stuartii* as a synonym).

*Cryptandra obovata auct. non* (Hook.) Hook.f.: Tate, *Handb. Fl. Extratrop. S. Austral.* 97 (1890), *pro parte*.

**Fig. 3.** *Spyridium thymifolium*. **A** Shrub growing in Cox Scrub C.P., Fleurieu Peninsula; **B** flowering branches; **C, D** close-up of flowerheads, surrounded by densely felty floral leaves. — A, B *J. Kellermann 660 & F. Nge*, C, D *JK 656 & FN*. Photos by J. Kellermann.

*Shrubs* to 1.5 m high; young stems densely pubescent with white and rusty, spreading, long simple and stellate hairs. *Leaves* alternate: *stipules* broadly ovate to broadly triangular, 2–6.4 mm long, free and overlapping behind petiole, reddish-brown to almost black, glabrous, with hairs along midrib and ciliate towards apex; *petiole* 1.8–7 mm long, stellate pubescent; *lamina* ovate to broadly ovate or elliptic, 7.3–29 mm long, 3.2–22.5 mm wide (larger in young plants), base obtuse to cordate, margins flat to slightly recurved, apex acute to acuminate, sometimes emarginate, upper surface glabrous with only the midrib and secondary veins apparent, lower surface with a dense indumentum of white and rusty simple and stellate hairs, becoming grey when older, margin, midrib and veins with longer rusty hairs (the hairs on the margin usually visible from above). *Floral leaves* usually 2 or 3: broader and smaller than stem-leaves, (2.5–) 3.5–8 (–15) mm long, (2–) 3.5–7 (–12) mm wide, covered with a very dense, white, felty stellate indumentum. *Inflorescence* a dense axillary head of 10–30 cymosely arranged ± sessile flowers, 3–8 mm diameter; inflorescence *axis* (4–) 5.5–29 mm long, densely pubescent with rusty and white hairs; *bracts* broadly ovate to orbicular, 2.5–4 mm long, outside mostly glabrous, with dense long cilia. *Flowers* white to cream, sometimes slightly yellowish. *Hypanthium*: free tube 0.3–0.7 mm long, 0.6–1.4 mm diameter, with moderately dense, long simple hairs over minute stellate hairs; base similarly pubescent. *Sepals* 0.3–0.6 mm long, with dense, erect simple and stellate hairs, especially towards the tip. *Petals* 0.25–0.4 mm

**Fig. 4.** *Spyridium thymifolium* illustrations by J.M. Black on specimens from his own herbarium. **A, B** Cross section through flowers; **C** fruit, splitting into 3 fruitlets; **D** opened white papery fruitlet; **E** light coloured seed with dark mottling and darkened base; **F, G** inflorescence bracts. — A, D–G Square waterhole, *H.H.D. Griffiths s.n.* (AD97611140A); B, C near Victor Harbor, *Anon. s.n.* (AD97611139A). Ink and watercolour drawings by J.M. Black.

long, cucullate, shortly clawed; limb:claw ratio c. 3:1. *Stamens* subequal to the petals, c. 0.3 mm long; *anthers* 0.1–0.2 mm long. *Disc* smooth, glabrous, forming an undulating ring at the summit of the hypanthium tube (or slightly below). *Ovary* inferior, carpels 3, summit with dense, erect stellate hairs; *style* 0.3–0.6 mm long, entire, slightly 3-lobed at apex. *Infructescence* conspicuously expanding, so tiled bracts are visible. *Fruits* obovoid to ellipsoid, c. 1.8–2 mm long, 1.2–1.6 mm wide, consisting of 3 white papery fruitlets of which usually only 1–2 develop fully, torus in upper third, fruit wall ± glabrous, dark brown; *seeds* flattened obovoid to ellipsoid, 1.2–1.4 mm long, 0.9–1 mm wide, fawn with dark green to black mottling, base brown. **Figs 3 & 4.**

***Illustrations.*** J.M. Black, *Fl. S. Austral.* 2nd edn, 3: 548, Fig. 706 (1952); J.P. Jessop & H.R. Toelken, *Fl. S. Austral.* 818, Fig. 430E (1986); A. Prescott, *It's Blue With Five Pet. Adelaide* 143, Fig. 4 (1988), 2nd edn, 145, Fig. 4 (2012); G.R.M. Dashorst & J.P. Jessop, *Pl. Adelaide Plains Hills* 100, pl. XLIII, Fig. 10 (1990); W.R. Barker, *J. Adelaide Bot. Gard.* 21, Fig. 2C (1995), stipule only; A. Prescott, *It's Blue With Five Pet. Kangaroo Isl.* 50, Fig. 7 (1995).

***Distribution & habitat.*** The species mainly occurs on the Fleurieu Peninsula and extends to Kangaroo Island (Fig. 5). It often grows on light-coloured sandy soils and sandy loam, sometimes with lateritic or limestone pebbles; a few collections are from rocky soils. *Spyridium thymifolium* is found in heathland, open scrubland and occasionally in forests and woodlands.

***Phenology.*** Flowering and fruiting mainly in Sep.–Feb., and also during other times of the year.

***Affinities.*** The species can have quite broadly ovate to almost orbicular leaves, similar to *Spyridium phlebophyllum* (F.Muell.) F.Muell. from the Flinders Ranges, but that species can easily be recognised by the raised veins on the upper leaf surface. *Spyridium tricolor* W.R.Barker & Rye has rounder, thicker leaves with an emarginate apex and larger inflorescence bracts (Barker & Rye 1993). *Spyridium parvifolium* (Hook.) Benth ex F.Muell. also has similarly shaped leaves, but these are usually smaller in South Australian plants and have impressed secondary veins and hairs on the upper surface; that species also has more open inflorescences and less dense flower-heads (see Kellermann 2006). Typical for *S. thymifolium* is also that the rusty hairs along the leaf margin are usually visible from above (Fig. 3C). Characters to distinguish it from *S. bracteatum* are listed above.

***Typification.*** The typification and history of *Spyridium thymifolium* and *S. stuartii* Reissek & F.Muell. were discussed in Kellermann & Barker (2007). The authors indicated that type material of *S. thymifolium* should be sought in W, where Reissek worked, but they had not seen specimens from that herbarium. We have now located the specimen through the Jacq database

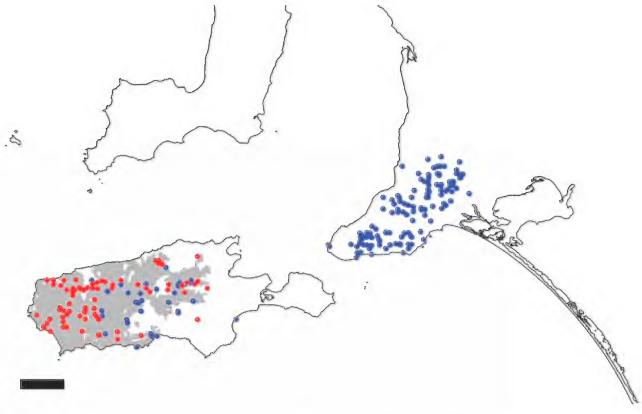

**Fig. 5.** Distribution map for *Spyridium bracteatum* (red) and *S. thymifolium* (blue), from specimens examined. The approximate area burnt during the 2019/20 Kangaroo Island bushfires is shaded in grey. Scale bar = 20 km.

(https://herbarium.univie.ac.at/database/) and it is here designated as the lectotype of the species.

Stuart "collected around Adelaide, Sturt R.[iver], lower Murray R. & Encounter Bay" (George 2009: 255) between July 1847 and March 1848; as such, the date on the isolectotype of *Spyridium thymifolium* at MEL must be in error.

***Common name.*** Thyme-leaved spyridium (Canning & Jessop 1986).

***Etymology.*** The epithet is Latin and refers to the resemblance of the leaves to those of the well-known herb of the genus *Thymus* L. (thyme).

***Selected specimens examined*** (c. 250 seen)

SOUTH AUSTRALIA. **Southern Lofty.** Mt Billy Conservation Park (C.P.), Gate 1, middle track, all around the first junction, 14 Nov. 2015, *C. Clowes CC285 & T. Schuster* (AD, MELU); Cox Scrub C.P., 27 Dec. 2015, *J.R. Guerin 256 & D.J. Duval* (AD, K); Martins Res. (Forestry SA), 10.9 km direct ESE of Delamere, 24 Feb. 2000, *R.S. Johnson & B.M. Routley BS117-857* (AD); Parson's Res., Waitpinga, 24 Nov. 1970, *D. Hunt 3247* (AD); Bullock Hill C.P., near sign, corner of Haines Rd and fire track, 3 Feb. 2008, *J. Kellermann 447 & A. Kellermann* (AD, B); Cox Scrub C.P., on walking track, c. halfway uphill, N end of park, 3 Feb. 2008, *J. Kellermann 457* (AD, K, LE, MEL); Cox Scrub C.P., S end, 24 Feb. 2008, *J. Kellermann 461 & I.M. Kellermann Williams* (AD, MEL; seedlings); Cox Scrub C.P., E side of Bond Rd, *J. Kellermann 462 & I.M. Kellermann Williams* (AD, B, BAA, CANB, E, HBG, M, MEL, NY); Cox Scrub C.P., fire track at S end in recently burned area, 14 Oct. 2018, *J. Kellermann 660 & F. Nge* (AD, B, MEL, W); Roadside vegetation adjoining S side of Congeratina Native Forest Res. (N side of Range Rd), 9 Oct. 2002, *P.J. Lang BSOP-546* (AD, KUN, NSW); Hundred of Myponga, Sect. 73, 45.5 km direct SSW of Myponga, 23 Nov. 1999, *P.J. Lang & D.M. Armstrong BS117-399* (AD, W); Stipiturus C.P., 6 Aug. 2009, *D.E. Murfet 6552* (AD); Wilson Hill, off Range Rd between Victor Harbor and Cape Jervis, 29 Oct. 1999, *J.G. West 5432* (AD, CANB, MEL); c. 20 km towards Victor Harbor, from Cape Jervis turnoff, 13 Oct. 1963,

*D.J.E. Whibley 1279* (AD, MO, NY, SI). **Kangaroo Island.** E of Pardana, 30 Sep. 1995, *W.R. Barker 7567, F. Udovicic, R.M. Barker & J.G. West* (AD, MEL); Playford Hwy, 12.8 km E of Gosse Ritchie Rd, 12 Dec. 2006, *D.J. Duval 728, T.S. Te, E.A. Pilman & M.J. Thorpe* (AD, K); Road on W side of Harriet River, c. 1 km after South Coast Hwy, 14 Oct. 2009, *J. Kellermann 504A* (AD, B, NY); Hundred of Newland, Sect. 135, 10.5 km direct NNE of Mt Taylor, 9 Apr. 1991, *P.J. Lang D-8283* (AD); Tin Hut Creek junction with Playford Hwy, S side of Hwy, 15 Nov. 2006, *T.S. Te 093 & D.J. Duval* (AD, K); Playford Hwy, 5.1 km E of intersection with South Coast Rd, 30 Sep. 1995, *F. Udovicic 256* (AD, CANB, E, MEL, PERTH, SI).

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# *Spyridium longicor*, a new species from Western Australia (Rhamnaceae: Pomaderreae)

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**Abstract:** A molecular analysis of the genus *Spyridium* Fenzl has shown that the phrase name taxon *Spyridium* sp. Jerdacuttup (*A. Williams 332*) WA Herbarium is distinct. It is described here as the new species *Spyridium longicor* Kellermann & C.Clowes. Illustrations and a distribution map are provided, as well as amendments for the Key to *Spyridium* in Western Australia.

**Keywords:** *Spyridium*, Rhamnaceae, Pomaderreae, new species

## Introduction

For many years, a long-leaved form of *Spyridium cordatum* (Turcz.) Benth has been known from the Raventhorpe area in south-west Western Australia, which was thought to be an intergrade between *S. cordatum* and *S. microcephalum* (Turcz.) Benth. Following a survey of the Raventhorpe Range in 2007 (Kern *et al.* 2008), where this entity was collected from the upper slopes of Bandalup Hill, herbarium collections were re-examined and subsequently this taxon recognised with the phrase name *Spyridium* sp. Jerdacuttup (*A.Williams 332*) WA Herbarium. Since then, more collections from this southern coastal region of Western Australia have been made and the taxon has been accepted in several publications and survey reports (e.g. Markey *et al.* 2011, 2012; Rathbone 2013; Wilkins *et al.* 2011; Woodman Environmental 2020).

Clowes *et al.* (2022) assembled an extensively sampled phylogeny of *Spyridium* Fenzl, including two accessions of *Spyridium* sp. Jerdacuttup. While the results of nrDNA data (including ITS and partial ETS sequences) placed the two accessions into a polytomy with *S. cordatum*, *S. microcephalum*, *S. majoranifolium* (Fenzl) Rye and other Western Australian species of *Spyridium*, the analysis of cpDNA (full chloroplast) data clearly placed the two samples of *Spyridium* sp. Jerdacuttup into one clade with full support, which was positioned within a larger clade of WA species, similar to the results from nrDNA. The two samples were collected from localities that were over 100 km apart (as indicated in the specimen list below).

Herbarium and field assessment has shown that *Spyridium* sp. Jerdacuttup can be consistently distinguished from *S. cordatum* and *S. microcephalum* morphologically, and we here describe it as the new species *Spyridium longicor* Kellermann & C.Clowes. Wilkins *et al.* (2011) provided a description of the species; this is here expanded with data from more recently collected specimens, including new information on fruit and seed characters.

## Taxonomy

### ***Spyridium longicor*** Kellermann & C.Clowes, ***sp. nov.***

*A* Spyridio cordato *(Turcz.) Benth. similis, sed foliis longioribus angustioribusque, inflorescentibus grandioribus et floribus longioribus differt.*

**Holotypus:** 11.45 km N along West Point Rd from Ravensthorpe-Esperance Rd, 13 Sep. 2008, *R. Butcher RB 1288 & A. Markey* (PERTH8023476). **Isotypi:** AD, B, CANB.

*Spyridium* sp. Jerdacuttup (*A.Williams 332*) WA Herbarium, *FloraBase: W. Austral Fl.* (2007) [online] https://florabase.dpaw.wa.gov.au/browse/profile/31916 [accessed: 14 Oct. 2021].

Perennial, sprawling to erect, dwarf *shrubs* to 0.4 m high and c. 1 m wide; young stems densely pubescent. *Hairs* on vegetative parts (unless otherwise mentioned) straight to flexuous, too entangled to discern if they are stellate or simple (but probably a mixture of both), ± matted, rusty when young, soon becoming white or grey, often looking dirty grey. *Leaves* alternate: *stipules* triangular to narrowly triangular, 1.7–3.5 mm long, free but overlapping, reddish brown with a long tip when very young, soon becoming grey, quite hairy especially in the middle, persistent after the leaves are shed; *petiole* 1–2.8 (–3) mm long, densely pubescent; *lamina* ovate


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**Key to species**

The identification key in Rye (1996) should be amended, as follows:

**7:** Leaves linear to broadly ovate or cordate, not folded, with distinctly recurved or revolute margins; bracts 1.5–3 mm long

**8.** Leaves cordate or broadly ovate, 2–5 mm long, usually as wide as long; petioles often indistinct; flower-heads 2.5–5.5 (–7) mm diam.; overall length of a single flower (base to sepals) < 2 mm [shrub to 0.5 m high; stipules and bracts hairy outside; petiole to 2 (–2.2) mm long; petals shortly clawed] . . . . . ***S. cordatum***

**8:** Leaves usually linear to oblong or ovate, sometimes elliptic or ovate, 4–9 mm long, longer than wide; petioles indistinct to distinct; flower-heads 4–6.5 (–9) mm diam.; overall length of one flower > 2 mm

**8a.** Shrubs to 1.5 m high; leaves usually < 1.5 mm wide, very narrowly ovate to linear or oblong, straight; base truncate to cuneate; apex acute to mucronate or obtuse (especially in the Cape Arid area); lower surface usually obscured by revolute margins with only the midrib visible; petioles obscure, to 2 mm long; stipules and bracts outside with few hairs; petals with a distinct claw to 0.2 mm long . . . . . ***S. microcephalum***

**8b:** Prostrate to erect shrublets to 0.4 m high; leaves > 1.5 mm wide, ovate to narrowly ovate, leaf blade often recurved; base truncate; apex obtuse; lower surface usually visible; petioles obvious, to 3 mm long; stipules and bracts quite hairy outside; petals with a very short claw to 0.1 mm long . . . . . ***S. longicor***

to narrowly ovate or elliptic, (2.5–) 3–8 mm long, 1.5–2.5 mm wide, tip often recurved; base obtuse to truncate; margins strongly recurved to revolute, apex obtuse, rarely acute or slightly emarginate, upper surface smooth to muricate with midrib impressed, sometimes with a few thin stellate hairs when young; lower surface usually visible, densely pubescent. White felty *floral leaves* absent, the inflorescence-subtending leaves similar to vegetative ones. *Inflorescence* a dense, axillary or terminal head of 17–25 cymosely arranged, ± sessile flowers, 4–7.5 mm diam. (expanding in fruit), when young often rusty in appearance; inflorescence *axis* 1–2 mm long, densely pubescent; *bracts* ovate to orbicular, 1.8–2 mm long, rusty to brown, densely hairy especially in middle, the margins ciliate. *Flowers* white to cream, sometimes rusty when very young. *Hypanthium tube* 0.5–0.8 mm long, 0.9–1.5 mm diam., moderately to densely pubescent with long, ± loosely appressed hairs; base similarly pubescent. *Sepals* 0.8–1.2 mm long; lobes erect to spreading, with a similar indumentum, but denser towards the tips. *Petals* c. 0.5 mm long, cucullate, enclosing the anthers, often yellow, indistinctly clawed (the claw to 0.1 mm long). *Stamens* subequal to the petals, c. 0.45 mm long, erect to incurved; *anthers* c. 0.15 mm long. *Disc* smooth, glabrous, comprising triangular lobes between the stamens and positioned almost at the summit of the hypanthium tube. *Ovary* inferior, carpels 3, ovary summit pubescent with dense erect hairs; *style* 0.9–1.1 mm long, entire, slightly 3-lobed at apex, with a few hairs in bottom third. *Fruit* an obovoid to ellipsoid schizocarp 2–2.5 mm long, c. 1.8 mm wide, releasing 3 white papery fruitlets of which usually only 1 or 2 develop fully, torus in upper third, fruit wall sparsely hairy, dark brown to black; *aril* thin, white to yellow, translucent, easily detached from seed and often remaining in fruitlet when it breaks open; *seeds* flattened-obovoid to -ellipsoid, 1.4–1.6 mm long, c. 1 mm wide, fawn to light brown with a few dark mottles, the base dark brown. **Fig. 1.**

***Illustrations:*** A. Markey *et al.*, *Rep. Conserv. Status 74 Taxa Ravensthorpe Range* 197 (2011); C. Wilkins *et al.*, *Rare Poorly Known Fl. Raventhorpe Range & Bandalup Hill* 149 (2011); both photos.

***Distribution & habitat.*** *Spyridium longicor* occurs in the Esperance and Mallee Bioregions (SEWPAC 2013), scattered from near Gairdner and Jerramungup townships, in Fitzgerald River National Park (N.P.) and eastwards to Bandalup Hill, Cheadanup Nature Reserve (N.R.), Wittenoom Hills (Mt Burdett N.R.) and with easternmost populations near Condingup (Fig. 2). It grows in shallow white sand over lateritic clay and yellow-grey to reddish brown sandy clays, sometimes with lateritic gravel, on plains and on upper hillslopes, mainly in low open mallee over a dense myrtaceous and proteaceous shrub understorey.

***Phenology.*** Flowering Aug.–Nov. (–Dec.).

***Affinities.*** *Spyridium cordatum* differs from *S. longicor* in having shorter and broader leaves (usually as wide as long) with cordate bases, and smaller flower-heads with shorter flowers. *Spyridium microcephalum* differs in being a larger shrub with narrower, linear to oblong leaves to 1.5 mm wide, the lower surface usually obscured by the margins, and stipules and bracts with fewer hairs outside. See the identification key for further differences.

***Conservation status.*** The species is not listed as threatened in Western Australia, having been delisted

**Fig. 1.** *Spyridium longicor* at the type locality, West Point Road, c. 60 km east of Ravensthorpe. **A** Habitat, with the species growing directly at the base of the tree; **B** habit (small prostrate shrub); **C** branches with leaves, flowering and fruiting inflorescences; **D** close-up of flower-head. — Photos: A, C A. Markey; B, D R. Butcher.

in 2010 from priority status under the Conservation Codes for Western Australian Flora (Wilkins *et al.* 2011; Markey *et al.* 2012; Smith & Jones 2018). It is conserved in Fitzgerald River N.P. and in some smaller reserves, such as Cheadanup and Speddingup (A36183) N.R. Some populations have been impacted by recent mining activities (i.e. Bandalup Hill) and others are likely to have been impacted by historical clearing for agriculture.

***Etymology.*** From the Latin *longior* (long) and *cor* (heart), in reference to the leaves that are longer than in *Spyridium cordatum*. It is to be treated as a noun in apposition.

### *Specimens examined*

WESTERN AUSTRALIA. 11.45 km N along West Point Rd from Ravensthorpe-Esperance Rd, 13 Sep. 2008, *R. Butcher RB 1287 & A. Markey* (AD, PERTH); West Point Rd, rise S of Oldfield River, N of Coujinup Tk on both sides of the road, 16 Oct. 2017, *C. Clowes CC533 & M.W. Pratt* (AD, MEL, MELU; DNA voucher); 11.45 km N of Ravensthorpe-Esperance Hwy on West Point Rd, 30 Aug. 1992, *G.F. Craig 1997* (PERTH); c. 5 km NW of Young River crossing on Ravensthorpe-Esperance main road (Young River is c. 70 km W of Esperance), 25 Sep. 1968, *E.N.S. Jackson 1290* (AD, CANB, PERTH); South Coast Hwy, 20 km S of Jerramungup, roadside reserve W of Hwy, 1 Oct. 2001, *J. Kellermann 394* (AD, B, MEL); Ravensthorpe Range, survey site R193, 30.1 km ESE of Ravensthorpe, located on E slope of Bandalup Hill, c. 800 m E of Mason Bay Rd, 9 Oct. 2007, *S. Kern & R. Jasper LCH 18194* (AD, BM, PERTH); Speddingup N.R. (A36183), road verge on causeway on Robins Rd, 11 Oct. 2016, *E. Massenbauer 786* (PERTH); Speddingup N.R., 460 m E of SW corner, 55 km NW Esperance, 2 Apr. 2017, *K.R. Mills KR738* (AD, K, MELU, MO, NSW; DNA voucher); 4.5 km from West Point Rd along Rawlinson Rd, Cheadanup N.R., 26 Sep. 1985, *L.J. Nunn 303* (PERTH); Wittenoom Hills, c. 3 km W of Mount Burdett (Wittenoom Hills is c. 50 km NE of Esperance), 4 Oct. 1968, *A.E. Orchard 1349* (AD, PERTH; GZU, GOET *n.v.*); c. 32 km NNE of the coast at Stokes Inlet, 18 Oct. 1968, *A.E. Orchard 1627* (AD, CANB; L, OSH, PERTH *n.v.*); Jerdacuttup Rd, S boundary of Oldfield Loc. 779, 54 km SE of Ravensthorpe, 16 Dec. 2001, *A. Williams 332* (PERTH).

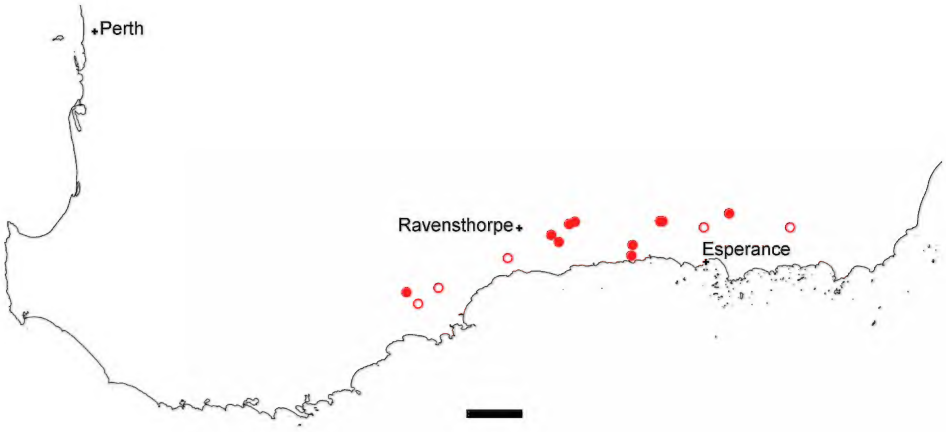


**Fig. 2.** Distribution of *Spyridium longicor* in southern Western Australia. Specimens examined indicated as full circles; locations of other specimens at PERTH determined as *Spyridium* sp. Jerdacuttup as open circles. Scale bar = 50 km.

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Kat Ticli (AD) is thanked for scoring the vegetative characters and mapping the new species. We thank Barbara Rye (PERTH) for encouraging us to write this paper. Adrienne Markey and Ryonen Butcher (PERTH) provided images of *Spyridium longicor*. The project "A new phylogeny of the Australian Rhamnaceae, revision of *Cryptandra* and *Spyridium*, and completion of the *Flora of Australia* treatment of the family" is supported through funding from the Australian Government's Australian Biological Resources Study (ABRS) National Taxonomy Research Grant Programme. Catherine Clowes was supported by a Holsworth Wildlife Research Endowment (The Ecological Society of Australia), and the Hansjörg Eichler Scientific Research Fund (Australasian Systematic Botany Society).

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SHORT COMMUNICATION

# Inadvertent lectotypifications of Australian *Dillenia* and *Tetracera* (Dilleniaceae)

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*Dillenia* L. and *Tetracera* L. (Dilleniaceae) were revised by R. D. Hoogland in 1952 and 1953 respectively. The Australian species *Dillenia alata* (R.Br. ex DC.) Banks ex Martelli and *Tetracera daemeliana* F.Muell. were treated in these revisions (Hoogland 1952, 1953), where they were inadvertently lectotypified by Hoogland indicating the "holotype" for each name (see McNeill 2014). Hoogland's use of the term "holotype" is to be corrected to "lectotype" according to Art. 9.10 of the *International Code of Nomenclature for algae, fungi, and plants* (hereafter ICN; Turland *et al.* 2018). This correction is possible as before 2001 it was not necessary to use the phrase "here designated" or an equivalent when lectotypifying names (ICN Art. 7.11). Because multiple sheets exist at the designated herbaria, there may be some confusion as to which specimen is the lectotype. In this paper I clarify typification of these names, preparatory to a treatment of Australian Dilleniaceae for the *Flora of Australia*. Digital images of all type specimens were viewed on the JSTOR Global Plants website (https://plants.jstor.org).

### ***Dillenia alata*** (R.Br. ex DC.) Banks ex Martelli

in Becc., *Malesia* 3: 157 (1886). — *Wormia alata* R.Br. ex DC., *Syst. Nat.* 1: 434 (1817). — *Lenidia alata* (R.Br. ex DC.) Poir. in Cuvier, *Dict. Sci. Nat.* Ed. 2, 25: 448 (1822). — **Type citation:** "Hab. in Novâ-Hollandiâ ad flumen Endeavour, *J. Banks* [...] (v.s. sp.)". — **Lectotype:** New South Wales [*sic*; now Queensland]: Endeavour's River, Point Lookout, 1770, *J. Banks s.n.* (BM000573950), *fide* Hoogland, *Blumea* 7(1): 50 (1952), as "holotype". **Isolectotypes:** BM000551305, G00201228, P00682292; E *n.v.*, *fide* Hoogland, *loc. cit.* **Possible isolectotype:** New Holland [Australia], *s.dat.*, *J. Banks s.n.* (BM000573953).

*Dillenia alata* Banks ex DC., *Syst. Nat.* 1: 434 (1817), *nom. inval. pro syn.*

*Dillenia alata* Banks ex Poir. in Cuvier, *Dict. Sci. Nat.* Ed. 2, 25: 448 (1822), *nom. inval. pro syn.*

*Wormia alata* was described by Candolle (1817b) based on a Joseph Banks collection from Endeavour River (modern Queensland), made during the 1770 voyage of HMB *Endeavour* along the east coast of the Australian mainland. However, a type was not explicitly designated (ICN Art. 9.1, Turland *et al.* 2018). In the protologue Candolle indicated that Banks had used the unpublished name *Dillenia alata* for this taxon, but Candolle adopted the manuscript name he acknowledged as being previously used by Robert Brown. The combination *Dillenia alata* was subsequently made by Martelli (1886), citing "Banks in DC."

In his revision, Hoogland (1952: 50) typified *Wormia alata* as follows: "Banks, New S. Wales, Endeavour Riv., Point Look Out; holotype in BM, isotypes in E, P". The JSTOR Global Plants website includes five digital images of sheets of *Dillenia alata* collected by Banks, at three herbaria: three specimens are held at BM, and one each at G-DC and P. I was unable to locate a sheet at E through a search of the herbarium catalogue; if the specimen exists, it has not yet been databased. A sixth digital image on JSTOR Global Plants of *Dillenia alata* is preserved at LINN (LINN-HS976-5), but does not include a location, date, or collector.

Sheet P00682292 was annotated by Hoogland in December 1950 as "typ. dupl.". He annotated BM 000573950 and BM000551305 in January 1951, the former as "type" [his underlining] and the latter as "type collection". An additional specimen of *D. alata* collected by Banks in Australia at BM (BM000573953) is annotated with a determinavit slip by Hoogland that is also dated January 1951. The specimen label reads "Dillenia alata - D. D. Banks - New Holland", leaving it unclear where in Australia it was collected. The specimen is a good match for the material mounted on the large sheet BM000573950. However, the *Endeavour* landed at other locations in what is now Queensland and within the modern-day distribution of *D. alata*. This specimen may or may not have been collected from the Endeavour River, and I therefore consider it a possible


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isolectotype. Among these three sheets at BM, only BM000573950 carries an original label in Banks's hand (see Marshall 1978), and the sheet was annotated "type" by Hoogland. It is also the only specimen with a label bearing the exact collection locality listed by Hoogland (1952: 50): "Endeavour Riv., Point Look Out". Among the specimens cited by Hoogland (1952), it is clear that he considered BM000573950 as the "holotype".

In March 1973, subsequent to his 1952 revision, Hoogland annotated a sheet of *D. alata* collected by Banks at Endeavour River and held at G-DC (G00201228) as the "HOLOTYPE". Following ICN Art. 9.19 (Turland *et al.* 2018), this is an error, as the author who first designates a lectotype must be followed, although the first choice of lectotype is superseded if the holotype is found to exist. It is, however, unlikely that there is a holotype, as Candolle's monographic work *Regni vegetabilis systema naturale* (in which the name was published) was based on the examination of specimens from many private herbaria (Stafleu 1967).

Additionally, it is known that de Candolle visited London in January 1816, where he was allowed to work in Banks' herbarium and library (Mabberley 1985: 197). It is also likely that, while in London, de Candolle discussed with Brown his manuscript names and descriptions of Dilleniaceae (Mabberley 1985: 203), as de Candolle thanked Brown in the preface of *Regni vegetabilis systema naturale* for sharing information on Australian species (Candolle 1817a: 8). Furthermore, the sheet G00201228 is annotated "m[isit] Rob. Brown 1816", presumably being sent to de Candolle following his visit to the Banks herbarium in January 1816 and after he had already examined the sheets in London.

The location specified on G00201228 is "Endeavour River", lacking the location "Point Look Out", where Banks also collected material and included together with material from Endeavour River on the sheet BM000573950. The other duplicates lack labels specifying a location, but presumably all material that originated from Banks's herbarium (including the material subsequently sent to de Candolle) was mixed from the two locations, as indicated by Banks's original label on BM000573950. The omission of the second location on the specimen at G-DC is likely an error that was duplicated in the protologue. As BM000573950 was collected from Endeavour River (as well as Point Lookout) and was available to de Candolle prior to the preparation of the protologue, it cannot therefore be excluded as original material (ICN Art. 9.4a; Turland *et al.* 2018).

From this, it is reasonable to believe that de Candolle's description of *Wormia alata* was not based solely on the specimen in his own herbarium (G00201228), and therefore a holotype does not exist for this name. The material from Banks's gathering, represented in multiple herbaria, would have had the status of syntypes prior to the publication by Hoogland (1952). Consequently, the inadvertent lectotypification by Hoogland (1952) is therefore followed according to ICN Art. 9.19 (Turland *et al.* 2018), making the specimen BM000573950 the lectotype.

### *Tetracera daemeliana* F.Muell.

*Fragm.* 5: 191 (1865). — **Type citation:** "In vicinia promontorii Cape York, ubi Parinario Griffithiano et Xeroti Banksii consociata. E. Daemel." — **Lectotype:** Cape York, Queensland, October [*s. anno*], *E. Daemel s.n.* (MEL2283231), *fide* Hoogland, *Reinwardtia* 2(2): 212 (1953), as "holotype". **Isolectotypes:** BRI-AQ0341730, K000687306, MEL2283232.

Hoogland (1953: 212) gave the typification for *Tetracera daemeliana* as follows: "Daemel *s.n.*, Cape York, October, holotype in MEL, isotype in BRI". There are two Daemel sheets of *Tetracera daemeliana* at MEL. Hoogland annotated only one of these (MEL 2283231), on which he wrote "type!". In addition, this is the only sheet that is annotated with the collecting month ("Octbr"). It is clear that Hoogland accepted MEL2283231 as the holotype, which is correctable to lectotype under ICN Art. 9.10 (Turland *et al.* 2018). This sheet is thus here regarded as the lectotype for the name *Tetracera daemeliana*, with MEL2283232 being an isolectotype. The sheets at BRI and K include labels from Hoogland that read "typ. dupl.", and are isolectotypes.

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# A new species of *Quintinia* (Paracryphiaceae) and an overview of the genus for New Guinea

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**Abstract:** A new species of *Quintinia* A.DC. is described, *Q. macrophylla* Hatus. ex O.K.Paul, and the typifications of all other species occurring in New Guinea are reviewed. An identification key to all 13 species accepted for the area is provided, as well as an Appendix with a checklist of all species in the genus. Lectotypes are chosen for *Quintinia altigena* Schltr., *Q. epiphytica* Mattf., *Q. lanceolata* Reeder, *Q. ledermannii* Schltr., *Q. macgregorii* F.Muell., *Q. nutantiflora* Schltr., *Q. pachyphylla* Schltr. and *Q. schlechteriana* O.C.Schmidt.

**Keywords:** *Quintinia*, Escalloniaceae, Paracryphiaceae, Quintiniaceae, Saxifragaceae, typification, new species, Indonesia, Western New Guinea, Papua New Guinea, checklist

## Introduction

The genus *Quintinia* A.DC. is comprised of c. 25 species (Appendix 1) of evergreen trees or shrubs, sometimes epiphytic, native to the Philippines, Sulawesi (Indonesia), New Guinea (and some adjacent islands), New Caledonia, Vanuatu, New Zealand and Australia. It was first described by Candolle (1830), who named it after Jean-Baptiste de la Quintine, a French gardener. The taxonomic history of the genus was summarised by Pillon & Hequet (2019). Previously, *Quintinia* has been assigned to Saxifragaceae, Escalloniaceae, or to its own family Quintiniaceae; molecular data now place it into Paracryphiaceae (Dickison & Lundberg 2016, and references therein).

The genus has not been revised recently for New Guinea, which has a high species diversity of *Quintinia*. Cámara-Leret *et al.* (2020) recognised 12 species in their checklist of New Guinea plants, of these, 11 species are recorded in Papua New Guinea (PNG), the eastern half of the island of New Guinea, and 10 species occur in Western New Guinea (Indonesia).

Mueller (1892) described the first species from the then British Territory of Papua in a short note in *Victorian Naturalist*: *Quintinia macgregorii* F.Muell., named after the collector, Sir William MacGregor, who found it at Mt Suckling in the Owen Stanley Range. This was followed by Schlechter (1914, 1917), who discussed the genus, enumerated all then known species and described four new taxa from the colonies of Dutch and German New Guinea: *Quintinia ledermannii* Schltr., *Q. altigena* Schltr., *Q. nutantiflora* Schltr. and *Q. pachyphylla* Schltr., the last three collected during the A. Franssen Herderschee Expedition (Duuren & Vink 2011).

This was followed by the description of five species in the papers of Ridley (1916), Schmidt (1924), Mattfeld (1940) and Reeder (1946), who discussed the results of scientific expeditions or described single collections that were examined by them: *Quintinia rigida* Ridl., discovered at Mt Carstensz (Puncak Jaya), during the Wollaston Expedition (Ridley 1916); *Q. schlechteriana* O.C.Schmidt from Mt Doorman; *Q. epiphytica* Mattf. from Sambanga (above present day Kabwum); *Q. brassii* Reeder from near Lake Habema; and *Q. lanceolata* Reeder from Idenburg River (both in then Netherlands New Guinea) (see also Frodin & Gressit 1982 and Frodin 2007 for more information on the exploration of New Guinea).

Royen (1983) was the last botanist to treat the genus in his *Alpine Flora of New Guinea*, where he enumerated and described six species from high altitudes, two of these new to science: *Quintinia montiswilhelmii* P.Royen and *Q. kuborensis* P.Royen. Since then, there were occasional reports of undescribed taxa, manuscript names were mentioned in publications or on determination-slips on herbarium specimens and proposed type specimens were


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labelled as such, but none of these suggested new taxa have been formally described (e.g. Streimann 1983; Al-Shammary 1991; Al-Shammary & Gornall 1994; Johns *et al.* 2009).

In New Guinea, the distribution of *Quintinia* ranges from lowland rainforests to high montane moss forest. The genus is not restricted to any particular habitats or vegetation types, but is distributed across the different altitudinal ranges. However, *Quintinia kuborensis* and *Q. montiswilhelmii* are two species that grow in the high montane moss forest zones. Since *Quintinia* species are mainly small to medium sized shrubs or trees (to 30 m), the wood is mainly used for fuel wood, building homes and fences; bark and leaves are used for medicinal purposes in different parts of PNG (pers. obs.).

In this paper we describe a new species, *Quintinia macrophylla* Hatus. ex O.K.Paul, a manuscript name used by Sumihiko Hatushima for plants that we recognise here as a new species. The taxon is illustrated, a distribution map is provided, as well as an identification key to the genus for New Guinea.

## Material and Methods

The morphological analysis was conducted using herbarium sheets. *Quintinia* specimens held in LAE were examined to score their vegetative and reproductive character and character-states.

Herbarium acronyms follow Thiers (2008). In this paper, specimens that were examined in person are indicated with an exclamation mark (!). Digital images of all other specimens were viewed online at JSTOR Global Plants (JSTOR 2021) or via other herbarium websites (Appendix 2). Specimens that have not been seen in person or as an image are indicated by "*n.v.*".

Provinces are used when listing distributions in Indonesian Western New Guinea. The geographical regions for PNG are taken from Womersley (1978).

References used for the etymology of the names are Jackson (1900), Steenis-Krusemann & Steenis (1950) and Stearn (1983).

### Key to *Quintinia* species in New Guinea

**1.** Epiphytes or vines, not shrubs or trees . . . . . ***Q. epiphytica***
**1:** Shrubs or trees
  **2.** Leaves slightly greyish underneath (in fresh material) . . . . . ***Q. altigena***
  **2:** Leaves glossy or pale green underneath (when fresh)
    **3.** Leaves thickly coriaceous, less brittle, leathery when dry
      **4.** Leaf margin entire, distinctively revolute . . . . . ***Q. rigida***
      **4:** Leaf margin entire, flat, not distinctively revolute
        **5.** Leaves lower surface black punctate or dark punctate . . . . . ***Q. pachyphylla***
        **5:** Leaves lower surface glabrous, pale glossy green
          **6.** Leaves larger, broadly obovate-oblong, 10–25 × 5–10 cm, apex obtuse or rounded . . . . . ***Q. macrophylla***
          **6:** Leaves smaller and narrower, elliptic to oblanceolate, (4–) 6–9 × 1.5–2.5 cm, apex obtuse or acute . . . . . ***Q. brassii***
    **3:** Leaves thinly coriaceous or subcoriaceous, brittle when dry
      **7.** Calyx lobes prominent, > 2 mm long . . . . . ***Q. nutantiflora***
      **7:** Calyx lobes less prominent, < 2 mm long
        **8.** Petal apex retuse . . . . . ***Q. macgregorii***
        **8:** Petal apex acute, obtuse or rounded
          **9.** Inflorescence less than 10 flowers, leaves distinctively small, usually < 6 cm long
            **10.** Leaf lamina ovate, small, 0.5–1.5 × 0.5–1 cm . . . . . ***Q. montiswilhelmii***
            **10:** Leaf lamina elliptic-lanceolate, 1–6 × 0.7–2.5 cm . . . . . ***Q. kuborensis***
          **9:** Inflorescence more than 10 flowers; leaves large, usually > 6 cm long
            **11.** Petioles > 10 mm long; leaves elliptic-lanceolate, apex acute
              **12.** Leaves elliptic-lanceolate; venation not prominent below . . . . . ***Q. ledermannii***
              **12:** Leaves lanceolate; venation prominent below . . . . . ***Q. lanceolata***
            **11:** Petioles < 10 mm long; leaves oblong-obovate, apex obtuse, rounded . . . . . ***Q. schlechteriana***

## Taxonomy

### *Quintinia altigena* Schltr.

*Bot. Jahrb. Syst.* 52(1-2): 127 (1914); *Nova Guinea* 12: 488 (1917). — **Type citation:** "Nördl. Neu-Guinea: Auf offenem Terrain des Hubrechts-Gebirges, ca. 3100 m ü.M. (E. Versteeg n. 2414 — blühend im Februar 1913)." **Lectotype:** INDONESIA, Western New Guinea: Mt Hubrecht, 3100 m, 7 Feb. 1913, *G.M. Versteeg 2414* (BO, missing or destroyed), *fide* P.Royen, *Alpine Fl. New Guinea* 4: 2509 (1983), as "Holotype". **New lectotype (here designated):** B 10 0715391. **Isolectotypes:** L0035121; L0035122; U0226125.

***Note.*** Schlechter (1914) described this species from a Versteeg collection, a photograph of which was published in Schlechter (1917) in the account of the results of the A. Franssen Herderschee Expedition. As he worked in Berlin (Stafleu & Cowan 1985), the main set of Schlechter's collections and type specimens can be found in that herbarium. The specimen of *Q. altigena* at B, cited above, has an original drawing of dissected flowers attached to it (Fig. 1A). One of the type specimens in Leiden (L0035121) seems to have been used for the photograph in Schlechter (1917), but the branch has been damaged.

Royen (1983) stated that the holotype of the species can be found in BO. This could be accepted as an inadvertent lectotypification of the name (Art. 9.10; Turland *et al.* 2018), however, even after an extensive search, that specimen cannot be found (I. Erlinawati, pers. comm., Nov. 2021). It is possible that Royen assumed that the type was in BO, but only examined a duplicate from another herbarium, or the specimen is no longer extant. Another explanation might be that "BO" is a printing error, and that Royan actually meant to write "B". However, it is impossible to prove this and the typification has to be taken as it was printed.

Since the specimen is missing from BO, but there is still original material available in other herbaria, we designate a new lectotype above, using the specimen at B (Art. 9.3). All other specimens of *Versteeg 2414* are isolectotypes.

***Distribution.*** Indonesia, Western New Guinea: West Papua and Papua provinces. Papua New Guinea: West Sepik, Morobe, Western Highlands, Eastern Highlands, Southern Highlands, Northern, Central and Milne Bay.

***Etymology.*** From the Latin *altus* (high) and *genus* (born, produced), referring to the habit of the plant; it is the only larger tree described by Schlechter (1914, 1917) from that expedition.

### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **West Papua.** Vogelkop Peninsula, Mt Tembruk, Aggi Gita Lake, 28 Jan. 1962, *H.O. Sleumer & M. Vink BW 15406* (L, LAE!); Wondiwoi Mountains, Wandamman Peninsula, 6 Mar. 1962, *P.A.W. Schram BM 13377* (L, LAE!). **Papua.** Jayapura, 15 km SW of Bernhard Camp, Idenburg River, Jan. 1939, *L.J. Brass 11856* (L, LAE!; A, *n.v.*).

**PAPUA NEW GUINEA. Morobe.** Manggak-ngone, 5 km E of Wagau, 14 Nov. 2004, *B.J. Conn 5050, K.D.Q. Damas, K.M. Fazang, O.K. Paul & T.K. Kuria* (L, LAE!, NSW).

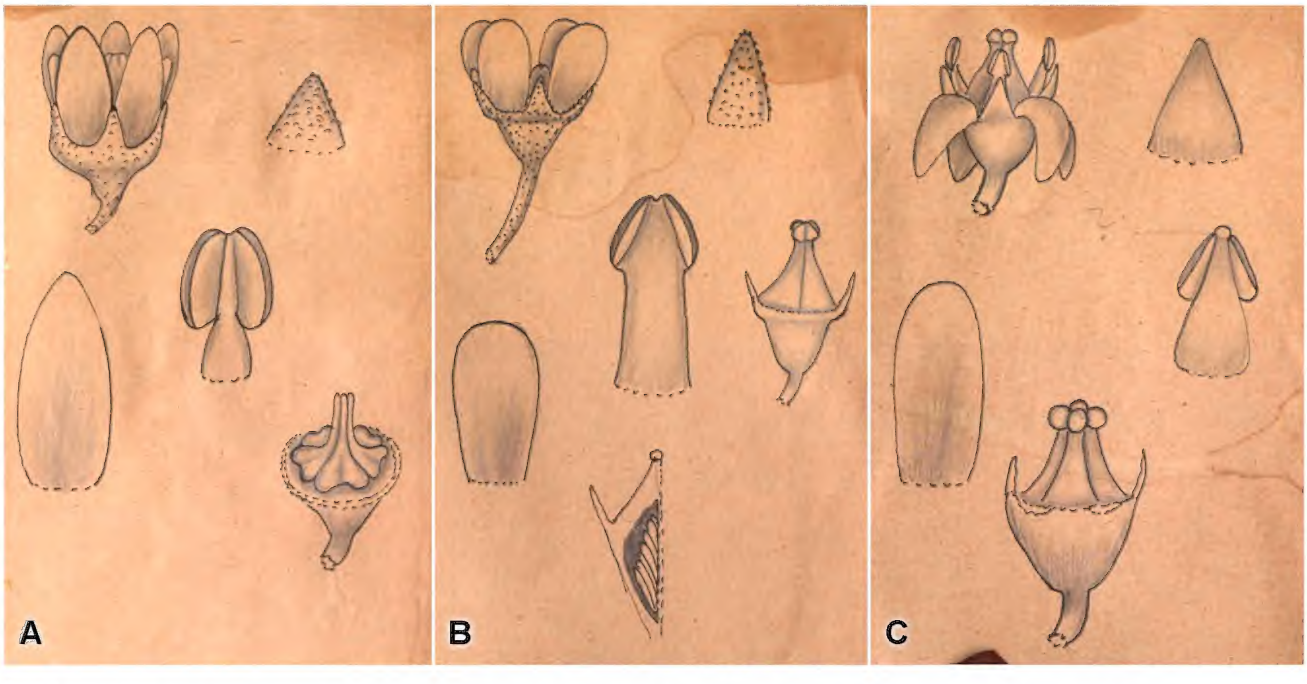


**Fig. 1.** Original line drawings of flowers, attached to the lectotype sheets at B of three *Quintinia* species named by Rudolf Schlechter, presumably drawn by Schlechter or an assistant. **A** *Quintinia altigena* (B 10 0715391); **B** *Q. nutantiflora* (B 10 0715389); **C** *Q. pachyphylla* (B 10 0715390). — © Botanischer Garten und Botanisches Museum Berlin-Dahlem, reproduced under a *Creative Commons CC BY-SA 3.0* licence.

**Southern Highlands.** Western summit grasslands of Mt Giluwe, 7 May 2012, *O.K. Paul 11* (LAE!, NSW). **Western Highlands.** Ecological Site No 2, 1.5 miles N of Lutheran Mission sawmill at Pockenamanda, near Wabag, 9 Feb. 1965, *J.R. Flenley ANU 2432* (LAE!; CANB, *n.v.*). **Eastern Highlands.** Mt Ormogadzin, W of Mt O Dan [Mount Udon], Sepik-Wahgi Divide, 5 Sep. 1963, *P. van Royen NGF 18073A* (L, LAE!, NSW; A, BO, BRI, CANB, K, SING, *n.v.*).

### *Quintinia brassii* Reeder

*J. Arnold Arbor.* 27: 280, Fig. 1A–C (1946). — **Type citation:** "Netherlands New Guinea: 6 km. northeast of Lake Habbema, alt. 3200 m., *Brass 11007* (Type), Oct. 1938". **Holotype:** INDONESIA, Western New Guinea: 6 km NE of Lake Habbema, 3200 m, Oct. 1938, *L.J. Brass 11007* (A, *n.v.*). **Isotypes:** BRI-AQ0022611; L0035128.

*Quintinia insularis* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 437 (1991), *nom. inval.*

*Quintinia* 'B': Gornall & Al-Shammary, *Bot. J. Linn. Soc.* 114: 131 (1994).

***Note.*** Reeder (1946: 275) wrote that "[I]n the absence of parenthetical letters indicating the place of deposit, cited specimens are to be found only at the Arnold Arboretum." As the "Type" specimen listed in his paper does not have a herbarium indicated and Reeder was not aware that there were duplicates at other herbaria, the specimen at A is the holotype of *Quintinia brassii*. We confirmed that the holotype is at A, but the specimen was not available for study at the time of writing (M. Schmull, pers. comm., Nov. 2021). However, there are two isotypes at BRI and L, which are available online (JSTOR 2021).

Al-Shammary's manuscript name "*Q. insularis*" was used in some publications, e.g. by Johns *et al.* (2009).

***Distribution.*** Indonesia, Western New Guinea: Papua Province. Papua New Guinea: West Sepik, Morobe, Southern Highlands, Eastern Highlands and Milne Bay.

***Etymology.*** Named after the Australian botanist and explorer Leonhard John Brass (1900–1971), who collected the type specimen.

#### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **Papua.** Snow Mountains, 6 km NE of Lake Habbema, Oct. 1938, *L.J. Brass 11007* (L, LAE!; BRI, *n.v.*).

**PAPUA NEW GUINEA. West Sepik.** Star Mts Expedition, Mt Capella summit ridge, c. 2 km SE of on Ridge W of Tel Basin, 7 Apr. 1975, *W.R. Barker & T. Umba LAE 67265* (BRI, L, LAE!; A, CANB, K, *n.v.*). **Morobe.** Wagau, 12 Jan. 1965, *C.D. Sayers, NGF 21597* (BRI, LAE!). **Southern Highlands.** Mt Ambua near Lei Camp, 29 July 1966, *D. Frodin NGF 26999* (BRI, LAE!; E, *n.v.*). **Eastern Highlands.** Slopes of Kerigomna, 11 Nov. 1968, *A.N. Millar NGF 40674* (BRI, L, LAE!; BISH, BO, CANB, NSW, US, PNH, SING, *n.v.*). **Milne Bay.** South Fergusson Island, Track between Ailuluai and Agamoia, 3 Nov. 1976, *J.R. Croft et al. NGF 68677* (BRI, L, LAE!, NSW; A, BISH, BO, CANB, E, K, M, PNH, QRS, SING, US, *n.v.*; proposed type of "*Q. insularis*").

### *Quintinia epiphytica* Mattf.

*Bot. Jahrb. Syst.* 70: 469 (1940). — **Type citation:** "Nordost-Neuguinea : Sambanga, 1500–1800 m ü. M., auf hohen Bäumen des Bergwaldes (M.S. Clemens n. 7168, am 22. September 1937, fruchtend; Typus Hb. Berol.)." **Lectotype (here designated) or perhaps holotype:** PAPUA NEW GUINEA: Morobe, Sambanga, 5–6000ft, 22 Sep. 1937, *M.S. Clemens 7168* (B 10 0715398).

***Note.*** We were only able to trace one specimen of *Clemens 7168*, however it is possible that duplicates exist, as Clemens' collections are distributed in several overseas herbaria. As such, the specimen from B, where Mattfeld worked, is above designated as the lectotype of the name; if only one specimen is in existence (Art. 40.3) then this would be the holotype (McNeill 2014; Mosyakin *et al.* 2019).

***Distribution.*** Indonesia, Western New Guinea: West Papua Province. Papua New Guinea: West Sepik, East Sepik, Morobe, Western Highlands and Southern Highlands.

***Etymology.*** The epithet is referring to the plant's epiphytic habit. In the publication, Mattfeld (1940: 469) referred to a note by Clemens, which stated that this was a "common scandent shrub on largest trees in mossy bush […] fl.[owers] too high to see" (see also Reeder 1946).

#### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **West Papua.** Vogelkop, Kebar Valley, 28 Oct. 1954, *P. van Royen 3855* (L, LAE!); Vogelkop, Mt Nettoti, Nettoti Range, path from Andjai to Wekari River, 30 Nov. 1961, *P. van Royen & H. Sleumer 7898* (BRI, L, LAE!; A, BO, CANB, K, RSA, US, *n.v.*); Vogelkop, Nettoti Range, hill W of Mt Nettoti, Cape Vogel, 1 Dec. 1961, *P. van Royen & H. Sleumer 7947* (L, LAE!; A, BO, BRI, CANB, K, RSA, US, *n.v.*).

**PAPUA NEW GUINEA. East Sepik.** Ambunti, Hunstein Range, 9 Aug. 1966, *R. Schodde 10879* (L, LAE; A, K, BO, BRI, US, *n.v.*). **Morobe.** Mt Missim, Wau, 18 Apr. 1986, *J.L.C.H. van Valkenburg 701* (L, LAE!; WAG, *n.v.*). **Southern Highlands.** Tari, Lei River, SE foot of Mt Ambua, 23 Aug. 1966, *C. Kalkman 5194* (L, LAE!). **Western Highlands.** Murmur Pass, Tomba-Tambul Road, 11 July 1971, *J. Womersely & B.C. Stone NGF 43751* (LAE!).

### *Quintinia kuborensis* P.Royen

*Alpine Fl. New Guinea* 4: 2501, Fig. 728A–C (1983). — **Type citation:** "Holotype. Kalkmann 4965, (L)." & "Kubor Mts". **Holotype:** PAPUA NEW GUINEA: Southern Highlands, Tari, Mt Ambua, 3390 m, 28 July 1966, *C. Kalkman 4965* (L0035129). **Isotypes:** BISH30138, *n.v.*

*Quintinia (a)*: Kalkman & Vink, *Blumea* 18: 135 (1970), *pro parte.*

*Quintinia kuborensis* subsp. *huonensis* Gornall & Al-Shammary, *in sched.*, *nom. inval.*

***Note.*** Kalkman & Vink (1970) mention an unnamed *Quintinia* from the Doma Peaks region and they list several specimens, among them the collection that later became the holotype of *Q. kuborensis*, when Royen (1983) described the species.

Some herbarium specimens have been labelled with the manuscript name "*Quintinia kuborensis* subsp. *huonensis*", but this subspecies was never published.

This species is endemic to Papua New Guinea.

***Distribution.*** Papua New Guinea: Morobe, Western Highlands, Eastern Highlands and Southern Highlands.

***Etymology.*** The epithet refers to the type locality, Mr Kubor in the Kubor Range, PNG (4,359 m).

***Selected specimens examined***

**PAPUA NEW GUINEA. Morobe.** Domgin, Salawaket Range, Huon Peninsula, 5 Oct. 1964, *R.D. Hoogland 9997* (BRI, L, LAE!; A, CANB, K, US, *n.v.*; proposed type of "*Q. kuborensis* subsp. *huonensis*"). **Western Highlands.** Mt Kigum, around Base Camp, 8 Apr. 1977, *A. Vinas LAE 59820* (LAE!; BRI, *n.v.*). **Eastern Highlands.** Mt Wilhelm Keglsugl-Pindaunde Track, 4 July 1966, *L.K. Wade ANU 7340* (L, LAE!; A, BO, BRI, CANB, G, K, US, PHN, BISH, *n.v.*). **Southern Highlands.** Mt Kerewa, NW Slopes, 15 Sep. 1981, *J. Wiakabu & J. Veldkamp LAE 73704* (L, LAE!; A, BRI, CANB, K, *n.v.*).

### *Quintinia lanceolata* Reeder

*J. Arnold Arbor.* 27: 278 (1946). — **Type citation:** "Netherlands New Guinea: 15 km. southwest of Bernhard Camp, Idenbug River, alt. 1770 m., *Brass & Versteegh 11920* (Type), Jan. 1939". **Holotype:** INDONESIA, Western New Guinea: 15 km SW of Bernhard Camp, Idenburg River, 1770 m, Jan. 1939, *L.J. Brass & C. Versteegh 11920* (A, *n.v.*). **Isotypes:** BRI-AQ0022612; L0035130.

***Note.*** As with *Q. brassii*, above, Reeder (1946) did not indicate a herbarium when he mentioned the type specimen. As such, the holotype of the species is deposited at A, but the specimen was not available for study at the time of writing (M. Schmull, pers. comm., Nov. 2021). We examined images of the two isotypes online (JSTOR 2021).

Endemic to Western New Guinea. The species is not known from Papua New Guinea, but some specimens were collected close to the border and it is possible that it also occurs there.

***Distribution.*** Indonesia, Western New Guinea: West Papua and Papua provinces.

***Etymology.*** From the Latin *lanceolatus* (lanceolate), referring to the shape of the leaves of the taxon.

***Selected specimens examined***

**INDONESIA.** WESTERN NEW GUINEA: **West Papua.** Vogelkop, Mt Nettoti, Nettoti Range, Cape Vogel, path from Andjai to Wekari, 28 Nov. 1961, *P. van Royen & H.O. Sleumer 7381* (BRI, L, LAE!; A, BO, CANB, K, RSA, SING, US, *n.v.*). **Papua.** Jayapura, Cycloop Mts, path from Ifar to Ormoe, 28 June 1961, *P. van Royen & H.O. Sleumer 6068* (BRI, L, LAE!; BM, CANB, G, K, MAN, PNH, UC, *n.v.*).

### *Quintinia ledermannii* Schltr.

*Bot. Jahrb. Syst.* 52(1-2): 125–126, Fig. 3 (1914). — **Type citation:** "Nordöstl. Neu-Guinea: In den Wäldern auf dem Etappenberg, ca. 850 m ü. M. (C. Ledermann n. 9056 – blühend im October 1912); in den Nebelwäldern auf dem Lordberg, ca. 1000 m ü. M. (C. Ledermann n. 10167, 10293 – blühend im Dezember 1912)." **Lectotype (here designated):** PAPUA NEW GUINEA: Sepik area, Dec. 1912, *C.L. Ledermann 10293* (L0035132, ex B). **Residual syntypes:** Sepik area, Oct. 1912, *C.L. Ledermann 9056* (L0035131); Sepik area, Dec. 1912, *C.L. Ledermann 10167* (L0035133, ex B).

*Quintinia spathulata* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 437 (1991), *nom. inval.*

*Quintinia* 'D': Gornall & Al-Shammary, *Bot. J. Linn. Soc.* 114: 131 (1994).

***Note.*** The three specimens mentioned in the protologue were collected during the Kaiserin-Augusta Expedition (1912–1913) by Ledermann (Sauer 1915; Ledermann 1919). The main set of specimens used to be held at B (Steenis-Krusemann & Steenis 1950), however no type material of *Quintinia ledermannii* could be found at that institution (R. Vogt, pers. comm., Oct. 2021), i.e. it was most likely destroyed during WWII, as was most of Ledermann's collections (Veldkamp *et al.* 1988). Duplicates of all three collections are available at L, two of these labelled "Ex Museo botanico Berolinensis". Schlechter (1914) described the flowers of the species and illustrated flowers and inflorescences in detail. The sheet with the best flowering material is above designated as the lectotype.

Interestingly, both herbaria also hold another specimen of that species, which was collected during this expedition (Lordberg, Sepik area, 1 Dec. 1912, *C.L. Ledermann 9955*; B 10 1154548; L.1870990), but this was not mentioned in the protologue and is not type material.

***Distribution.*** Indonesia, Western New Guinea: Papua Province (Snow Mountains region). Papua New Guinea: West Sepik, East Sepik, Morobe, Western Highlands, Eastern Highlands, Southern Highlands, Western, Central, Northern and Milne Bay.

***Etymology.*** Named after the Swiss horticulturist and collector Carl Ludwig Ledermann (1875–1958).

### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **Papua.** Bernhard Camp, 4 km SW, Mar. 1939, *L.J. Brass 13703* (L, LAE!; A, BRI, *n.v.*); Bernhard Camp Idenburg River, Mar. 1939, *L.J. Brass 13132* (L, LAE!; A, BRI, *n.v.*); Ifar Ormoe camp site, 28 June 1961, *P. van Royen & H.O. Sleumer 6068* (L, LAE!; A, BM, CANB, G, MAN, PNH, UC, *n.v.*).

**PAPUA NEW GUINEA. East Sepik.** Hunstein Range, 29 Sep. 1989, *P. Katik LAE 64328 & A. Kairo* (BRI, L, LAE!, NSW; CANB, *n.v.*). **Morobe.** Kaindi, moss forest, 11 Aug. 1964, *A.N. Millar NGF 23622* (E, L, LAE!; A, BISH, BO, BRI, CANB, HAW, K, NSW, SING, PNH, US, *n.v.*; proposed type of "*Q. spathulata*"); Opuseng, Cromwell, 26 Oct. 2006, *O.K. Paul LAE 88514, T.M.A. Utteridge, W.J. Baker, R.P.J. de Kok, K.D.Q. Damas, B.B. Bau, D. Damas & K.M. Fazang* (LAE!, NSW; A, CANB, BRI, K, L, UPNG, *n.v.*); Mt Kaindi, 27 June 1973, *P.F. Stevens & G.W. Gillet LAE 58809* (BRI, L, LAE!; A, BISH, CANB, E, K, M, NSW, *n.v.*). **Western Highlands.** Waile road near Reservoir, small hill with power transformer substation, Porgera area, Enga, 6 Sep. 2005, *W. Takeuchi 20212, A. Towati & D. Ama* (L, LAE!). **Western.** NE side of Bianglopmik (Lake Vivian), a few meters N of Ok Abne 1, near entrance to lake, N of Biang Bluff, southern slopes of Star Mountains, 2 Nov. 2014, *B.J. Conn 5944, K.D.Q. Damas, D. Damas & P. Homot* (LAE!, NSW).

## *Quintinia macgregorii* F.Muell.

*Victorian Naturalist* 9: 112 (1892); *Bot. Centralbl.* 53: 27 (1893). — **Type citation:** "high up on Mount Suckling". **Lectotype (here designated):** PAPUA NEW GUINEA: Northern, Mt Suckling, 5–6000 [ft], 31 July 1891, *W. MacGregor s.n.* (MEL628127). **Isolectotype:** K000739372 (received Feb. 1892).

*Quintinia macgregori* F.Muell., *Victorian Naturalist* 8: 164 (1891), *nom. nud. & inval.*

***Note.*** As discussed by Reeder (1946), Mueller (1892) described the species in a very short note outlining the differences between *Q. macgregorii* and the Australian *Q. fawkneri* F.Muell. (see Zich *et al.* 2020). No specimens were listed in the publication, but there is one collection of the species available at MEL, which was collected by Sir William MacGregor. A duplicate specimen is available at K, bearing a blue "Phytologic Museum of Melbourne / Baron Ferd. Von Mueller, Ph. & M.D." label, i.e. it was distributed by Mueller to that herbarium. Both specimens were labelled by Mueller and contain some flowers and leaves; we assume they were available to him when preparing the publication. The sheet in MEL is in slightly better condition and is therefore designated as the lectotype, above.

The species is endemic to Papua New Guinea.

***Distribution.*** Papua New Guinea: Morobe, Western Highlands, Eastern Highlands, Southern Highlands, Central, Northern and Milne Bay.

***Etymology.*** The epithet honours Sir William MacGregor (1846–1919), Scottish doctor, administrator and later lieutenant-governor of British New Guinea (1888–1898).

### *Selected species examined*

**PAPUA NEW GUINEA. Western Highlands.** NE of Yaki River Valley, 2 July 1960, *R.D. Hoogland & R. Schodde 6893* (L, LAE!; BRI, CANB, *n.v.*). **Eastern Highlands.** Hillcrest behind Kerowagi, 1 Aug. 1957, *R.G. Robbins 633* (L, LAE!; BRI, CANB, *n.v.*). **Southern Highlands.** Track up to Mt Giluwe, 24 Sep. 1968, *J. Vandenberg, P. Katik & A. Kairo NGF 39719* (BRI, L, LAE!; A, BO, CANB, K, SING, *n.v.*); **Central.** Murray Pass, Wharton Rang, June 1933, *L.J. Brass 4719* (LAE!, NY; BRI, L, *n.v.*). **Milne Bay.** Mt Wadimana Summit area, E Mt Simpson Range, 19 July 1969, *R. Schodde 5500* (L, LAE!; A, BRI, CANB, CHR, K, *n.v.*).

## *Quintinia macrophylla* Hatus. ex O.K.Paul, ***sp. nov.***

*A* Quintinia nutantiflora *Schltr. foliis coriaceioribus grandioribusque, floribus pentameris et sepalis vix persistentibus differt.*

**Holotypus:** PAPUA NEW GUINEA: Morobe, Mt Kaindi, 2040 m, 14 Nov. 1963, *J.S. Womersley NGF 19031* (LAE57717!). **Isotypi:** BISH1014086, BRI-AQ35622; L.1871374; US03684170; SING0342779; K, A, BO, SYD, CANB, P, NH, *n.v.*

*Quintinia macrophylla* Hatus. in Streimann, *Plants Upper Watut Watershed* 173 (1983), *nom. nud. & inval.*; Valk. & Ketner, *J. Trop. Ecol.* 10: 46–47 (1994), *nom. nud. & inval.*; Byng, *Fl. Pl. Handbk.* 507 (2014), *nom. nud. & inval.*

*Quintinia macrophylla* Hatschb. in E.P.Beaver *et al.*, *Zootaxa* 4809(3): 467 (2020), *nom. nud. & inval.*

*Quintinia microphylla* Hatus. in B.J.Conn & Damas, *Guide Trees Papua New Guinea*, https://www.pngplants.org/PNGtrees (2006–), *in error*.

*Quintinia grandifolia* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 437 (1991), *nom. inval.*

*Quintinia* 'A': Gornall & Al-Shammary, *Bot. J. Linn. Soc.* 114: 131 (1994).

Small to large *tree*, 10–30 m high. *Bole* cylindrical (c. 20 cm diam.); straight (bole c. 10 m long); buttresses absent; no spines; no aerial roots or stilt roots. *Bark* brown, rough, pustular, lenticels elongated vertically, total thickness 10–12 mm; subrhytidome (under-bark) green or yellow; bark blaze consisting of one layer (when cut); faintly to non-aromatic; pleasant; outer blaze white or pale yellow (straw-coloured), with stripes, fibrous; inner blaze white (straw-coloured), with stripes, fibrous; bark exudate present, colourless, not readily flowing, colour changing to orange on exposure to air, not sticky. Mature *branches* glabrous, with lenticels. *Leaves* simple, alternate; lamina 13–25 × 4–8 cm, broadly obovate, base cuneate, apex obtuse, thickly coriaceous, glabrous; margin entire, mostly revolute; venation brochidodromous, not very distinct, primary venation impressed on the upper side, (30–) 50–80 (–100) pairs

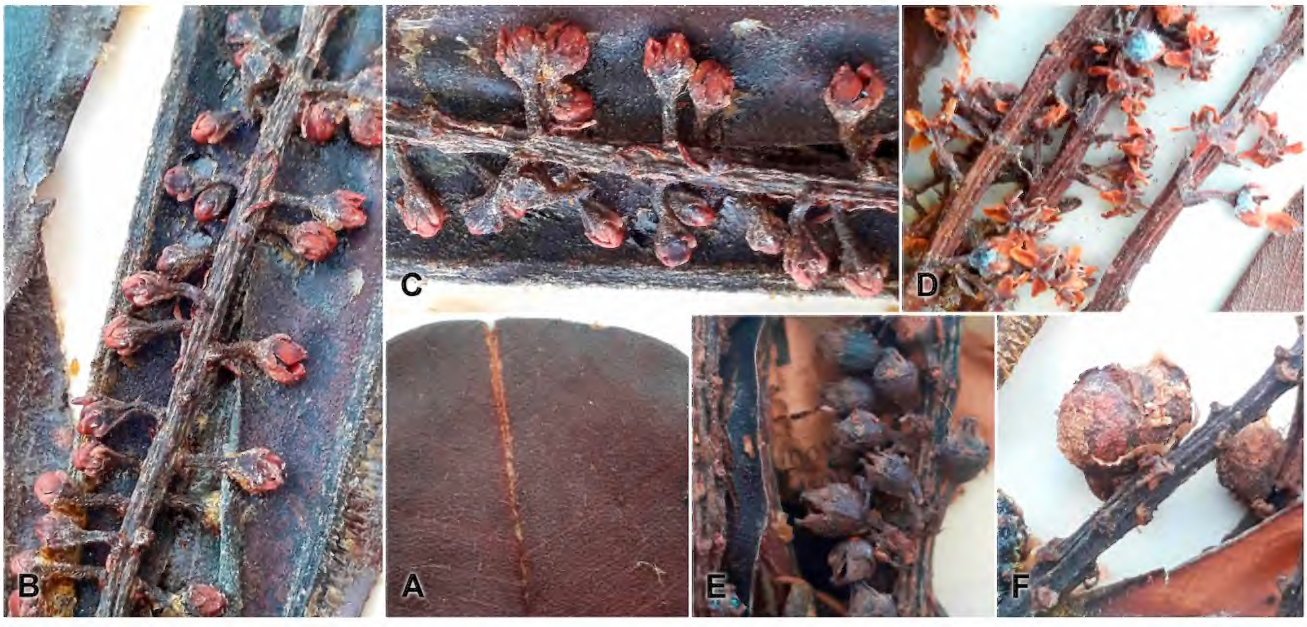


**Fig. 2.** *Quintinia macrophylla*. **A** coriaceous leaf, apex; **B, C** inflorescence axis with young flowers and buds; **D** open flowers; **E** young fruits; **F** mature fruits. — A, F *E.E. Henty, D.B. Foreman & M. Galore NGF 42819* (LAE), B, C *E.E. Henty, D.B. Foreman & M. Galore NGF 42760* (LAE), D *J. Regalado 1582* (LAE), E *J.R. Croft & V. Lelean LAE 6582* (LAE).

of secondary veins barely visible; petioles not winged, attached to base of leaf blade, not swollen, 1–3 cm long, glabrous; stipules absent. *Inflorescence* axillary, glabrous, racemose, 5–26 cm long, with 30–80 (–100) flowers on unbranched axis, bracts 1–2 mm, sometimes persistent. *Flowers* 4- or 5-merous; pedicels 2–5 mm. *Calyx* lobes triangular, 0.5–1 mm long, glabrous, free and persistent only on immature fruits. *Petals* free, oblong, 1–5 mm long, glabrous, white. *Stamens* white. *Style* persistent, 1–1.5 mm long. *Ovary* inferior, 4–5 locules, hypanthium glabrous. *Fruit* a capsule, glabrous, greenish yellow, ovoid, c. 10 × 10 mm, minutely ridged longitudinally. **Fig. 2, 3.**

***Illustration:*** J.W. Byng, *Fl. Pl. Handbk.* 507 (2014), fruit only.

***Affinities.*** This species is similar to *Quintinia nutantiflora*, having similar leaf shape and size, however, that species has consistently 4-merous flowers with distinctive calyx lobes, persistent on fruits, and its leaves are thinly coriaceous and brittle (Tab. 1). The thickly coriaceous leaves of *Q. macrophylla* are less brittle and cannot be broken in half easily.

***Distribution.*** The new species has been collected a few times in Western New Guinea (Indonesia) in higher elevations from the Vogelkop Peninsula to the Snow Mountains region. In Papua New Guinea it is found mainly along the Central Range (or Central Cordillera) from west to east. It occurs in the Star Mountains in the north-west and Muller Range in the south-west through Bismarck Range and into the Kuper Range. It has been collected from the following regions in Papua New Guinea: West Sepik, Western, Eastern Highlands, Southern Highlands and Morobe (Fig. 4).

***Habitat.*** Mid to high montane forest between 2000 to 3000 meters above sea level (Valkenburg & Ketner 1994). It is commonly found associating with

**Table 1.** Diagnostic characters of *Quintinia macrophylla*, compared with *Q. nutantiflora* and *Q. rigida*.

| | ***Q. macrophylla*** | ***Q. nutantiflora*** | ***Q. rigida*** |
|---|---|---|---|
| Leaf texture | Thickly coriaceous; less brittle | Thinly coriaceous to subcoriaceous; brittle | Thickly coriaceous; less brittle |
| Upper leaf surface | Brown on drying | Black on drying | Brown on drying |
| Leaf lamina length | 13–25 cm | 10–13 cm | (4–) 5–10 (–11) cm |
| Leaf apex | Obtuse-rounded | Acute | Retuse |
| Flowers | 4–5-merous | 4-merous | 4-merous |
| Calyx lobes | Less distinct & deciduous | Distinct & persistent on fruit | Less distinct |

HERB. LUGD. BAT.
L.1871374
FLORA OF NEW GUINEA
Botanical Collections of the Division of Botany, Department of Forests, Lae.
J. S. Womersley, N.G.F. 19031
14/11/63
Locality: Mt. Kaindi, Wau sub-district, Morobe District, T.N.G., lat. 7 20 S, long. 146 45 E, alt. 6,800 feet.
Habitat: Montane forest on moderate slope.
Annot: Tree, branching sparsely and vertically. Height 40 feet, bole 10 feet, d.b.h. 9 inches. Flowers white.
Fam. Saxifragaceae
Name: Quintinia
Dupl. sent to: Bri. Canb. A. K. L. Bog. Sing. Syd. B.M. Bish. U.S. P. N.H.
5 cm

**Fig. 3.** *Quintinia macrophylla* Hatus. ex O.K.Paul, isotype, *J.S. Womersley NGF 19031* (L.1871374). Insets: close-up of flowers. — Image from Naturalis Biodiversity Center, Leiden, reproduced under a *Creative Commons CC0 1.0* licence.

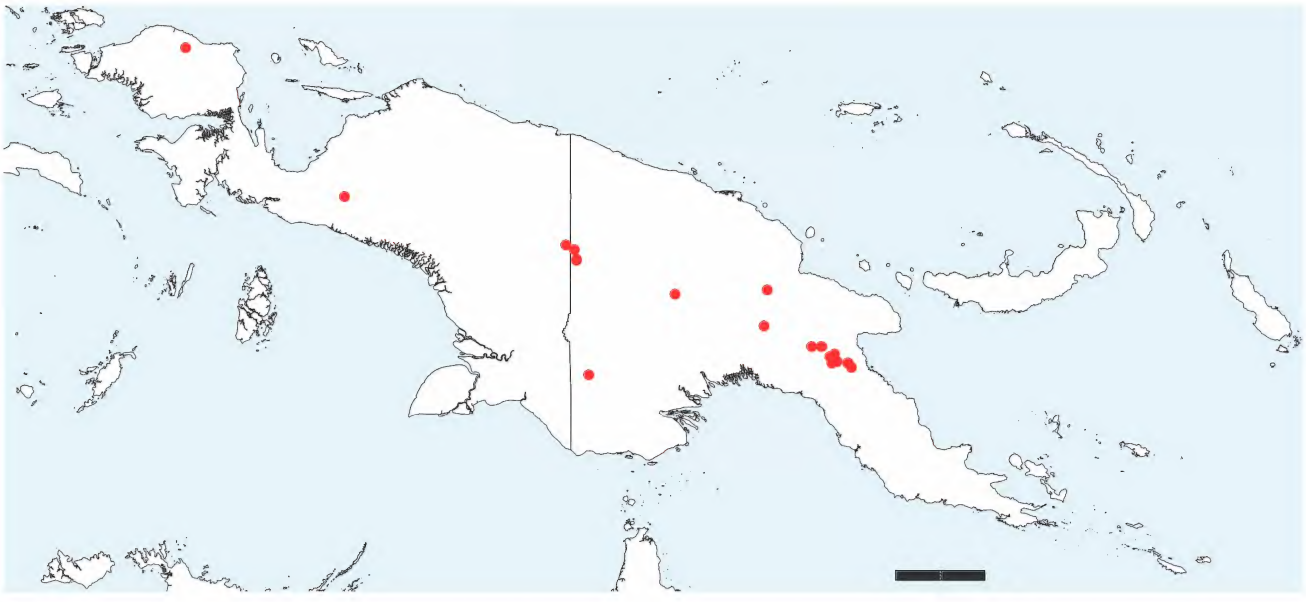

**Fig. 4.** Distribution map of *Quintinia macrophylla* in New Guinea, generated from specimens examined. Scale bar = 200 km.

*Podocarpus*, *Syzygium*, *Nothofagus*, *Elaeocarpus*, as well as tree ferns like *Cyathea* and *Dicksonia*.

***Conservation status.*** *Quintinia macrophylla* is a common species in the natural mid to high montane forests. Since it is generally not harvested for major uses such as timber and its natural habitat is still intact with no major developments and destructions, it is not regarded as vulnerable or threatened. Its estimated area of occupancy (AOO) in PNG is 100 km² and extent of occupancy (EOO) is 180,000 km², based on other *Quintinia* species assessed under IUCN guidelines IUCN (2021). As such, it is stable and of Least Concern (LC). The conservation status in Western New Guinea should be assessed.

***Notes.*** The new species seems to be restricted mostly in higher elevations in mid to high montane forests over 2000 meters above sea level (Valkenburg & Ketner 1994) and is widely distributed throughout Papua New Guinea, especially along the Central Cordillera (Fig. 4).

There are other *Quintinia* species associated with *Q. macrophylla*, which can be difficult to identify without a flower or fruit, i.e. *Q. rigida* and *Q. nutantiflora*. However, the thickly coriaceous leaves of *Q. macrophylla* are a field character that can be used to differentiate it from these other two *Quintinia* species. The leaves of *Q. macrophylla* are also much larger (lamina 13–25 cm long vs 10–13 cm in *Q. nutantiflora* and (4–) 5–10 (–11) cm in *Q. rigida*). *Quintinia nutantiflora* is similar to *Q. macrophylla*, but *Q. nutantiflora* has more prominent calyx lobes than *Q. macrophylla*.

In error, Conn & Damas (2006–) used the epithet "*microphylla*" in the online *Guide to trees of Papua New Guinea*.

***Etymology.*** The epithet is derived from the Greek μακρος (*makros*, large) and φυλλον (*phyllon*, leaf), in reference to the very large leaves of the species.

***Authorship.*** The name was originally coined by Japanese botanist Sumihiko Hatusima (1906–2008; Hotta 2008) and several specimens in different herbaria are annotated with his manuscript name. We recognise Hatusima's contribution to New Guinean botany by taking up this epithet for the new species and citing him as an "ex" author. While Kanehira & Hatusima (1942) published on related genera, Hatusima's findings on *Quintinia* never appeared in print.

The database entry for the L specimens at *Naturalis* all show in error "Hatschb." (Gerdt Guenther Hatschbach, Brazilian botanist, 1923–2013; Ferreira da Silva & Ferraz de Oliveira 2008) as author of this manuscript name, even though on the actual specimens the name is attributed to "Hatus." or "Hats.", the former being the official abbreviation of Hatusima's surname (IPNI 2021), the latter another less commonly used abbreviation (e.g. Kokubugata *et al.* 2012; Matsuda *et al.* 2017). Unfortunately, this error was perpetuated in publications, with the name "*Quintinia macrophylla* Hatschb." having been used in at least one scientific paper (Beaver *et al.* 2020).

### *Additional specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **West Papua.** Kebar Valley, Mt Watjetoni, 23 Nov. 1960, *C. Versteegh BW 10332* (L, LAE!). **Papua.** Star Mountains, Mt Antares, 20 July 1959, *C. Kalkman 4459* (L, LAE!; A, BM, BO, CANB, M, *n.v.*); Wissel Lake region, slope and summit of Mt Barara, 4 Sep. 1939, *P.J. Eyma 5133* (L; BO, *n.v.*).

**PAPUA NEW GUINEA. West Sepik.** Telefomin, north slopes of Star mountains, 8 Apr. 1975, *J.R. Croft & V. Lelean LAE 65824* (BRI, L, LAE!; A, CANB, E, K, *n.v.*); Telefomin, Silinmogu, below Tamanagabip, 9 May 1975, *A. Vinas &*

*J. Wiakabu LAE 59399* (L, LAE!; A, BRI, CANB, K, *n.v.*). **Morobe.** Eddie Creek, 2 Sep. 1974, *A. Alison AA-NG 113* (LAE!); Mt Kaindi, 17 Sep. 1978, *D.G. Frodin UPNG 6545* (LAE!; UPNG, *n.v.*); Bulldog Track, 7 May 1963, *T.G. Hartley TGH 11807* (LAE!; BRI, CANB, *n.v.*); Gumi TRP area, 10 Apr. 2006, *O. Paul LAE 87729* (LAE!, NSW; K, *n.v.*); Watut Range, 13 Aug. 1995, *J. Regalado 1582* (LAE!, NY; F, GH, *n.v.*); Kaindi, 4 Nov. 1966, *C.E. Ridsdale NGF 30217* (L, LAE!); Bulolo, 17 Oct. 1982, *H. Streimann 8632* (L, LAE!; A, BFC, CANB, K, UPNG, *n.v.*); Mt Kaindi, 10 Sep. 1968, *J. Vandenberg & A.N. Millar NGF 39692* (L, LAE!; A, BISH, BO, BRI, CANB, K, PNH, SING, SYD, *n.v.*); near helicopter pad, Mt Kaindi, 18 Dec. 1968, *J. Vandenberg NGF 42162* (BRI, L ×3; A, CANB, K, *n.v.*; proposed type of "*Q. grandifolia*"). **Eastern Highlands.** Wara Semia, 10 km south-southwest of Maimafu, Crater Mountain, 29 Jan. 1999, *R. Jensen NG 155* (BRI); Keglsugl, trail to Mt Wilhelm, 5 Aug. 1994, *J. Regalado & P. Katik 1174* (NY, LAE!; F, *n.v.*). **Southern Highlands.** Ambua, Tari, 4 Aug. 1966, *D. Frodin NGF 28201* (L, LAE!). **Western.** Hong Kong hill, Ok Tedi headwaters, 29 Oct. 1969, *E.E. Henty, D.B. Foreman & M. Galore NGF 42760* (L, LAE!; A, BRI, CANB, K, *n.v.*); Edinburgh Camp, Ok Tedi headwaters, 30 Oct. 1969, *E.E. Henty, D.B. Foreman & M. Galore NGF 42819* (L, LAE!, US; A, BISH, BRI, BO, CANB, E, K, PNH, SING, SYD, *n.v.*); Muller Range, 19 Sep. 2009, *W. Takeuchi, D. Ama & B. Gamui 24635* (LAE!, L).

### *Quintinia montiswilhelmii* P.Royen

*Alp. Fl. New Guinea* 4: 2498, Fig. 728D–G (1983), as "*montiswilhelmi*". — **Type citation:** "Holotype. McVean & Wade ANU 7043, (L)." & "Mt Wilhelm". **Holotype:** PAPUA NEW GUINEA: Eastern Highlands, Slopes east of Lake Aunde, Mt Wilhelm, 17 May 1966, *D.N. McVean & L.K. Wade ANU 7043* (L0035134). **Isotypes:** LAE75340!; CANB, *n.v.*

***Note.*** The species is endemic to Papua New Guinea.

***Distribution.*** Papua New Guinea: Western Highlands, Eastern Highlands and Southern Highlands.

***Etymology.*** The epithet refers to the type locality, Mt Wilhelm in the Bismarck Range, the highest peak in PNG (4,509 m).

#### *Selected specimens examined*

**PAPUA NEW GUINEA. Western Highlands.** Nona-Minj Divide, Kubor Range, 5 July 1963, *W. Vink 16041* (L, LAE!; CANB, *n.v.*). **Eastern Highlands.** Slope of Imbuka Ridge, Lake Wilhelm area, 24 Aug. 1970, *B.G. Briggs 3772* (NSW); Pindua Aunde, Mt Wilhelm, Gembolg, Feb. 1970, *T. Umba NGF 43477* (L, LAE!; A, BO, BRI, CANB, K, NSW, *n.v.*). **Southern Highlands.** Tari, Mt Né, 8 July 1966, *W. Vink 17123* (L, LAE!).

### *Quintinia nutantiflora* Schltr.

*Bot. Jahrb. Syst.* 52(1-2): 127 (1914); *Nova Guinea* 12: 488 (1917). — **Type citation:** "Nördl. Neu-Guinea: Auf dem Hellwig-Gebirge, ca. 1900 m ü. M. (A. Pulle n. 84 – blühend im December 1912)." **Lectotype (here designated):** INDONESIA, Western New Guinea: Mt Hellwig, 1900 m, 27 Dec. 1912, *A.A. Pulle 841* (B 10 0715389). **Isolectotypes:** U0226124; L0035135.

*Quintinia macrocarpa* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 437 (1991), *nom. inval.*

*Quintinia* 'C': Gornall & Al-Shammary, *Bot. J. Linn. Soc.* 114: 131 (1994).

***Note.*** In the protologue, the collecting number is given in error as "81", however all Pulle collections seen from that location and date have the collecting number "841". This is an error to be corrected (Art. 9.2; Turland *et al.* 2018). The lectotype at B has original line drawings of flowers attached to the sheets (Fig. 1B). The isolectotype at L bears a *Determinavit* slip by Schlechter.

***Distribution.*** Indonesia, Western New Guinea: West Papua and Papua provinces. Papua New Guinea: West Sepik, Western Highlands, Eastern Highlands and Milne Bay.

***Etymology.*** The name is derived from the Latin *nutans* (nodding) and *flos* (flower), in reference to the loose, nodding flowers of the species.

#### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **West Papua.** Mt Sensenemes, Anggi Gigi Lake, 18 Jan. 1962, *H.O. Sleumer & M. Vink BW 14204* (L, LAE!; BRI, *n.v.*); Anggi Gita, Lake Testega, 13 Jan. 1962, *H.O. Sleumer & M. Vink BW 14117* (L, LAE!; BRI, *n.v.*); Tamrau Range, path from Sudjak village to Mt Kusemun, 4 Nov. 1961, *P. van Royen, H. Sleumer & F. Schram 7673* (L, LAE; A, BO, BRI, CANB, K, RSA, US, *n.v.*).

**PAPUA NEW GUINEA. West Sepik.** Torricelli Mountains, Mt Somoro, 31 Aug. 1961, *P.J. Darbyshire 324* (L, LAE!; CANB, *n.v.*). **Madang.** Mt Wilhelm, Plot 2200C, 28 Oct. 2012, *J.K. Munzinger 6815, J.-F. Molino, K.D.Q. Damas, K. Molem & J.-C. Pintaud* (LAE!, NSW, P; K, MPU, *n.v.*). **Western Highlands.** Minj-Nona Divide, N slopes of Kubor Range, 22 Aug. 1963, *R. Pullen 5209* (B, BRI, L, LAE!; CANB, *n.v.*; proposed type of "*Q. macrocarpa*"). **Eastern Highlands.** 2 miles N Waimambuno, 20 Aug. 1957, *J.C. Saunders 818* (L, LAE!; CANB, *n.v.*). **Milne Bay.** Mt Wadimann ridge, NE from Mt Simpson, 22 July 1969, *R. Pullen 7854* (L, LAE!; A, CANB, K, *n.v.*).

### *Quintinia pachyphylla* Schltr.

*Bot. Jahrb. Syst.* 52(1-2): 127 (1914); *Nova Guinea* 12: 489 (1917). — **Type citation:** "Nördl. Neu-Guinea: Auf den Nordhängen des Hellwig-Gebirges, ca. 2500 m ü. M. (A. Pulle n. 930 – blühend im Januar 1913)." **Lectotype (here designated):** INDONESIA, Western New Guinea: Mt Hellwig, 2500 m, 6 Jan. 1913, *A.A. Pulle 930* (B 10 0715390). **Isolectotypes:** U0226123; L.1871497; L0035137.

***Note.*** As other Schlechter types of *Quintinia* at B, the lectotype specimen also contains original drawings

of the flowers (Fig. 1C). The isolectotype L.1871497 is only fragmentary, but the other two isolectotype specimens from L and U are larger.

***Distribution.*** Indonesia, Western New Guinea: West Papua and Papua provinces (Snow Mountains region). Papua New Guinea: Morobe, Western Highlands and Eastern Highlands.

***Etymology.*** The epithet is derived from the Greek παχυς (*pachys*, thick) and φυλλον (*phyllon*, leaf), referring to the thick leaves of the species.

### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **West Papua.** Vogelkop, Mt Tembruk, Anggi Gita Lake, 28 Jan. 1962, *H.O. Sleumer & M. Vink BW 15406* (BRI, L, LAE; MAN, *n.v.*). **Papua.** 9 km NE of Lake Habbema, Oct. 1938, *L.J. Brass 10449* (BRI, L, LAE!; A, *n.v.*); 15 km SW of Bernhard Camp, Idenburg, Jan. 1939, *L.J. Brass 11983* (BRI, L, LAE!; A, *n.v.*).

**PAPUA NEW GUINEA. Morobe.** Eraulu Logging Area, 13 June 1974, *P. Katik LAE 62099* (BRI, L, LAE!; A, BISH, CANB, K, NSW, US, *n.v.*); Edie Ck 4 miles SW of Wau, 7 Jan. 1964, *C.D. Sayers sub T.G. Hartley 12588* (BRI, L, LAE!; CANB, *n.v.*). **Western Highlands.** W of Kawil, Jimmi Valley, 16 June 1955, *J.S. Womersley & A.N. Millar NGF 7685* (BRI, LAE!). **Eastern Highlands.** Kainantu-Okapa Road, 11 Aug. 1963, *T.G. Hartley 12143* (BRI, L, LAE!; CANB, *n.v.*).

## *Quintinia rigida* Ridley

*Trans. Linn. Soc. London, Bot.* 9(1): 38 (1916). — **Type citation:** "Camps XI to XIII, 8300 to 10,500ft". **Lectotype:** INDONESIA, Western New Guinea: Dutch New Guinea, A.F.R. Wollaston Expedition, [Mt Carstensz, Banderong valley,] Feb. 1913, *C. Boden Kloss s.n.* (BM000551644, annotated as "*Quintiniya* [*sic*] *rigida*"), *fide* P.Royen, *Alpine Fl. N. Guinea* 4: 2509 (1983), as "Holotype". **Isolectotype:** L0035139.

***Note.*** Royen (1983) inadvertently designated the specimen in BM as lectotype of the name by stating that it is the "Holotype" (Art. 9.10; Turland *et al.* 2018). It is a well-preserved specimen, annotated by Ridley. The detailed location description is taken from the isolectotype specimen at L.

***Distribution.*** Indonesia, Western New Guinea: Papua Province (Snow Mountains region). Papua New Guinea: Morobe, Central and Milne Bay.

***Etymology.*** From the Latin *rigidus* (stiff, inflexible), referring to the rigid leaves of the taxon.

### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **Papua.** Star Mountains, Mt Antares, 23 July 1959, *C. Kalkman 4488* (L, LAE!; A, BM, CANB, M, *n.v.*).

**PAPUA NEW GUINEA. Morobe.** Bakaia, about 15 miles SE of Garania, 24 Jan. 1964, *T.G. Hartley 12787* (BRI, CANB, LAE). **Central.** Above Kuputivava, Goilala, 12 Feb. 1964, *T.G. Hartley 13013* (L, LAE!; BRI, CANB, *n.v.*). **Milne Bay.** S slopes of Goe, Rabaraba, 12 July 1972, *P.F. Stevens & J.F. Veldkamp LAE 55512* (L, LAE!; A, BRI, CANB, K, *n.v.*); Idop Range, Road to Mt Simpson, 17 July 1968, *M. Galore NGF 17598* (LAE!).

## *Quintinia schlechteriana* O.C.Schmidt

*Nova Guinea* 14: 148 (1924). — **Type citation:** "Niederländisch Neu Guinea: Dormantop, 3260 m — H. J. Lam n. 1606 (Typus), blühend und fruchtend im Oktober 1920". **Lectotype (here designated):** INDONESIA, Western New Guinea: Nova Guinea neerlandica in reg. flum. Mamberami [Dutch New Guinea, Mamberamo river region], Mt Doormantop [Mt Anggemuk], 3260 m, 17 Oct. 1920, *H.J. Lam 1606* (B 10 1001193). **Isolectotype:** K000739373; L0035140; U0226122.

***Note.*** All type material was identified by Schmidt and these specimens are labelled as having been distributed by BO, however, no duplicate could be found at that institution (I. Erlinawati, pers. comm., Nov. 2021), i.e. it may be missing or is no longer extant. The specimen at B has Schmidt's notes and detailed line drawings of flowers attached (Fig. 5) and is above designated as the lectotype.

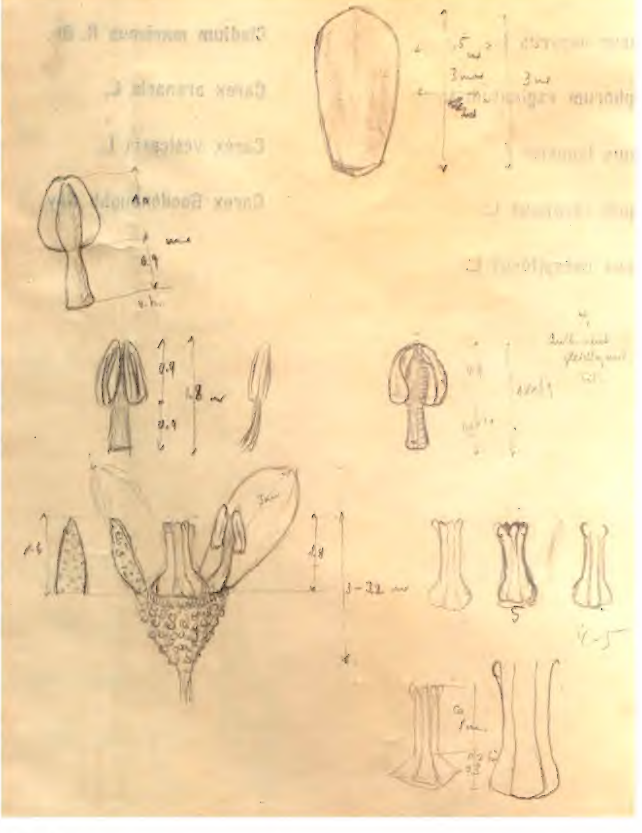

**Fig. 5.** Pencil drawings of a flower of *Quintinia schlechteriana* and its parts, attached to the lectotype in B; presumably drawn by O.C. Schmidt (B 10 1001193). — © Botanischer Garten und Botanisches Museum Berlin-Dahlem, reproduced under a *Creative Commons CC BY-SA 3.0* licence.

***Distribution.*** Indonesia, Western New Guinea: Papua Province (Snow Mountains region). Papua New Guinea: Morobe, Western & Western Highlands.

***Etymology.*** Named after the German botanist Friedrich Richard Rudolph Schlechter (1927–1925), who authored the first treatment of *Quintinia* in New Guinea (Schlechter 1914).

### *Selected specimens examined*

**INDONESIA.** WESTERN NEW GUINEA: **Papua.** Bele River, 18 km NE of Lake Habbema, Nov. 1938, *L.J. Brass 11453* (BRI, L, LAE!; A, *n.v.*).

**PAPUA NEW GUINEA. Morobe.** Kaindi, Aug. 1938, *J.B. McAdam 258* (BRI, LAE!). **Western Highlands.** Mt Kum near Mt Hagen, Apr. 1957, *J.S. Womersley NGF 9468* (L, LAE!). **Western.** Muller Range, Apalu Reke Camp 3, 19 Sep. 2009, *W. Takeuchi, D. Ama & B. Gamui 24767* (L, LAE!; A, *n.v.*); Muller Range, Apalu Reke Camp 3, 21 Sep. 2009, *W. Takeuchi, D. Ama & B. Gamui 24827* (L, LAE!; A, *n.v.*).

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**Appendix 1.** World checklist of *Quintinia*.
Information from IPNI (2021) and other publications and online resources, as indicated below.

***Quintinia*** A.DC., *Monogr. Campan.* 92 (1830), *in adnot.*
= *Curraniodendron* Merr., *Philipp. J. Sci., C* 5: 177 (1910).
= *Dedea* Baill., *Adansonia* 12: 338 (1879).

**New Zealand**[1] – Dawson & Lucas (2011), de Lange (2022).

***Quintinia serrata*** A.Cunn., *Ann. Nat. Hist.* 2(11): 356 (1839).
= *Quintinia serrata* var. *β* Hook.f., *Handbk. N. Zeal. Fl.* 59 (1864).
= *Quintinia acutifolia* Kirk, *Stud. Fl. New Zealand* 137 (1899).
= *Quintinia acutifolia* var. *lanceolata* Kirk, *Stud. Fl. New Zealand* 138 (1899).
= *Quintinia elliptica* Hook.f., *Bot. Antarct. Voy. II. (Fl. Nov.-Zel.)* 1: 78 (1852).
= *Quintinia serrata* var. *elliptica* (Hook.f.) Kirk, *Stud. Fl. New Zealand* 137 (1899).

**New Caledonia & Vanuatu** (*Q. media* only) – Pillon & Hequet (2019).

***Quintinia hyehenensis*** Pillon & Hequet, *Phytotaxa* 397(1): 49 (2019).
***Quintinia major*** (Baill.) Schltr., *Bot. Jahrb. Syst.* 52(1–2): 125 (1914).
≡ *Dedea major* Baill., *Adansonia* 12: 339 (1879).
***Quintinia media*** (Baill.) Guillaumin, *Bull. Soc. Bot. France* 86: 277 (1939).
≡ *Dedea media* Baill., *Adansonia* 12: 341 (1879).
= *Quintinia neoebudica* (Guillaumin) Guillaumin, *Ann. Mus. Colon. Marseille Sér.* 6, 5-6: 23 (1948).
= *Dedea neoebudica* Guillaumin, *J. Arnold Arbor.* 12: 250 (1931).
= *Quintinia parviflora* (Schltr.) Schltr., *Bot. Jahrb. Syst.* 52(1–2): 125 (1914).
= *Dedea parviflora* Schltr., *Bot. Jahrb. Syst.* 39(1): 115 (1906).
***Quintinia minor*** (Baill.) Schltr., *Bot. Jahrb. Syst.* 52(1–2): 125 (1914).
≡ *Dedea minor* Baill., *Adansonia* 12: 339 (1879).
= *Quintinia resinosa* (Schltr.) Schltr., *Bot. Jahrb. Syst.* 52(1–2): 125 (1914).
= *Dedea resinosa* Schltr., *Bot. Jahrb. Syst.* 39(1): 115 (1906).
***Quintinia oreophila*** (Schltr.) Schltr., *Bot. Jahrb. Syst.* 52(1–2): 125 (1914).
≡ *Dedea oreophila* Schltr., *Bot. Jahrb. Syst.* 39(1): 114 (1906).
***Quintinia sessiliflora*** Pillon & Hequet, *Phytotaxa* 397(1): 50 (2019).

**Australia** – Standley & Ross (1983), Zich *et al.* (2020), APC (2021), APNI (2021), AVH (2021).

***Quintinia fawkneri*** F.Muell., *Fragm.* 6(43): 92 (1867).
***Quintinia quatrefagesii*** F.Muell., *Victorian Naturalist* 7: 181 (1891).
***Quintinia sieberi*** A.DC., *Monogr. Campan.* 92 (1830).
***Quintinia verdonii*** F.Muell., *Fragm.* 2(15): 125 (1861).

**New Guinea** – Cámara-Leret *et al.* (2020), this paper.

***Quintinia altigena*** Schltr., *Bot. Jahrb. Syst.* 52(1–2): 127 (1914).
***Quintinia brassii*** Reeder, *J. Arnold Arbor.* 27: 280 (1946).
= *Quintinia insularis* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 437 (1991), *nom. inval.*
= *Quintinia* 'B': Al-Shammary & Gornall, *Bot. J. Linn. Soc.* 114: 131 (1994).
***Quintinia epiphytica*** Mattf., *Bot. Jahrb. Syst.* 70(4): 469 (1940).
***Quintinia kuborensis*** P.Royen, *Alpine Fl. New Guinea* 4: 2501 (1983).
***Quintinia lanceolata*** Reeder, *J. Arnold Arbor.* 27: 278 (1946).

[1] *Quintinia* in New Zealand is in need of revision. While "three ill-defined species" (Moore & Irwin 1978: 78) have been recognised in the past (e.g. Allan 1961: *Q. acutifolia*, *Q. elliptica* & *Q. serrata*), at the moment only one very variable species is accepted (Eagle 1982; Dawson & Lucas 2011; de Lange 2022).

***Quintinia ledermannii*** Schltr., *Bot. Jahrb. Syst.* 52(1–2): 125 (1914).
= *Quintinia spathulata* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 439–440 (1991), *nom. inval.*
= *Quintinia* 'D': Al-Shammary & Gornall, *Bot. J. Linn. Soc.* 114: 131 (1994).
***Quintinia macgregorii*** F.Muell., *Victorian Naturalist* 9: 112 (1892).
***Quintinia macrophylla*** Hatus. ex O.K.Paul, *Swainsona* 36: 110 (2022).
= *Quintinia macrophylla* Hatus. in Streimann, *Pl. Upper Watut Watershed Papua New Guinea* 173 (1983), *nom. nud. & inval.*
= *Quintinia grandifolia* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 437 (1991), *nom. inval.*
= *Quintinia* 'A': Al-Shammary & Gornall, *Bot. J. Linn. Soc.* 114: 131 (1994).
***Quintinia montiswilhelmii*** P.Royen, *Alpine Fl. New Guinea* 4: 2498 (1983), as "*montiswilhelmi*".
= *Quintinia* sp.: R.J.Johns & P.F.Stevens, *Bot. Bull. Dept. Forests Papua New Guinea* 6: 37 (1971).
***Quintinia nutantiflora*** Schltr., *Bot. Jahrb. Syst.* 52(1–2): 127. 1914.
= *Quintinia macrocarpa* Al-Shammary, *Syst. Stud. Saxifragac. S. Hemisph.* 438 (1991), *nom. inval.*
= *Quintinia* 'C': Al-Shammary & Gornall, *Bot. J. Linn. Soc.* 114: 131 (1994).
***Quintinia pachyphylla*** Schltr., *Bot. Jahrb. Syst.* 52(1–2): 127 (1914).
***Quintinia rigida*** Ridl., *Trans. Linn. Soc. London, Bot.* 9(1): 38 (1916).
***Quintinia schlechteriana*** O.C.Schmidt, *Nova Guinea* 14: 148 (1924).

**Mindanao (Philippines) & Sulawesi (Indonesia)** – Merrill (1923), Brambach (2019), GBIF (2021).

***Quintinia apoensis*** (Elmer) Schltr., *Bot. Jahrb. Syst.* 52(1-2): 125 (1914).
≡ *Dedea apoensis* Elmer, *Leafl. Philipp. Bot.* 2: 682 (1910).
≡ *Curraniodendron apoense* (Elmer) Merr., *Philipp. J. Sci., C* 10: 5 (1915).
= *Curraniodendron dedaeoides* Merr., *Philipp. J. Sci., C* 5: 177 (1910).
= *Dedea cinerea* Elmer, *Leafl. Philipp. Bot.* 8: 2824 (1915).

**Appendix 2.** Online herbarium websites searched for specimens

| | |
|---|---|
| Australasia's Virtual Herbarium | https://avh.chah.org.au |
| Consortium of Pacific Herbaria | https://serv.biokic.asu.edu/pacific/portal/index.php |
| JACQ | https://www.jacq.org |
| JSTOR Global Plants | https://plants.jstor.org |
| PNGplants | https://www.pngplants.org/PNGdatabase.html |
| A, GH — Harvard University Herbaria | https://kiki.huh.harvard.edu/databases/specimen_index.html |
| B — Herbarium Berolinense | http://ww2.bgbm.org/herbarium/default.cfm |
| BM — Natural History Museum, London | https://data.nhm.ac.uk |
| BR — Meise Botanic Gardens | https://www.botanicalcollections.be/ |
| E — Royal Botanic Garden Edinburgh | https://data.rbge.org.uk/search/herbarium/ |
| G — Geneva Herbarium | http://www.ville-ge.ch/musinfo/bd/cjb/chg/?lang=en |
| K — Royal Botanic Gardens Kew | http://apps.kew.org/herbcat/navigator.do |
| L, U — Naturalis Biodiversity Center | https://bioportal.naturalis.nl |
| MO — Missouri Botanic Gardens | https://www.tropicos.org/home |
| NY — New York Botanical Gardens | http://sweetgum.nybg.org/science/vh/ |
| P — Muséum national d'Histoire naturelle, Paris | https://science.mnhn.fr/all/search |
| US — Smithsonian (NMNH) | https://collections.nmnh.si.edu/search/botany/ |

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# Two new cremnophilous *Hibbertia* (Dilleniaceae) species from the Northern Territory

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**Abstract:** *Hibbertia* sp. Mount Howship (*C.R.Dunlop 6656*) and *H.* sp. South Magela (*K.G.Brennan 896*) from the Northern Territory are formally described here as *Hibbertia scopulicola* T.Hammer and *Hibbertia pendula* T.Hammer, respectively. Their distinguishing characters and morphological affinities with species in eastern Australia are discussed. A key to the groups and species of *Hibbertia* in the Northern Territory is provided.

**Keywords:** Australia, Dilleniaceae, *Hibbertia*, new species, Northern Territory, taxonomy

## Introduction

There are approximately 50 species of *Hibbertia* Andrews (Dilleniaceae) in the Northern Territory (N.T.), with most of these species belonging to *H.* subg. *Hemistemma* (Juss. ex Thouars) J.W.Horn, such as in the *H. melhanioides* and *H. tomentosa* groups (Toelken 2010). Eight species are members of *H.* subg. *Pachynema* (R.Br. ex DC.) J.W.Horn (Craven & Dunlop 1992; Horn 2009). There are only three species in the N.T. that are members of *H.* subg. *Hibbertia*, two of which are the phrase names *Hibbertia* sp. Mount Howship (*C.R.Dunlop 6656*) and *Hibbertia* sp. South Magela (*K.G.Brennan 896*). The only other member of *H.* subg. *Hibbertia* in the N.T. is *H. glaberrima* F.Muell. As part of the *Flora of Australia* project on *Hibbertia*, I present the taxonomic status of these two phrase names in *H.* subg. *Hibbertia* and formally describe them as the new species *Hibbertia pendula* T.Hammer and *H. scopulicola* T.Hammer.

### Key to species/groups of *Hibbertia* in the Northern Territory

**1.** Plants largely or completely leafless; petals white, yellow, pink or red . . . . . ***Hibbertia*** subg. ***Pachynema*** [8 spp.]

**1:** Plants leafy; petals yellow

**2.** Ovary (and often sepals) covered with peltate, silvery scales . . . . . ***Hibbertia*** subg. ***Hemistemma*** *p.p.* [31 spp.; *H. tomentosa* and *H. melhanioides* groups]

**2:** Ovary and sepals glabrous to hairy, lacking peltate scales

**3.** Fertile stamens all on one side of the carpels . . . . . ***Hibbertia*** subg. ***Hemistemma*** *p.p.* [7 spp.; *H. banksii-H. dealbata* group and *H.* sp. Chewings Range (*P.K. Latz 10660*)]

**3:** Fertile stamens all around the carpels

**4.** Flowers pedicellate; southern N.T. (e.g. MacDonnell Ranges) . . . . . ***Hibbertia glaberrima***

**4:** Flowers sessile; northern N.T. (West Arnhem Land)

**5.** Leaves (10–) 20–40 (–50) mm long, usually sparsely appressed-pubescent on both surfaces (rarely ± spreading-villous), ± concolorous, apex with a point 1–2 (–3) mm long; flowers 15–25 mm in diameter; two outermost sepals narrower than inner; anthers 1.5–2.5 (–3) mm long . . . . . ***Hibbertia scopulicola***

**5:** Leaves 5–12 (–15) mm long, adaxially densely to moderately erect-pubescent, abaxially densely appressed-sericeous, discolorous, apex rounded or with a mucro to c. 0.5 mm long; flowers 10–15 mm in diameter; two outermost sepals wider than inner; anthers 1.1–1.4 mm long . . . . . ***Hibbertia pendula***


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## Taxonomy

### *Hibbertia pendula* T.Hammer, *sp. nov.*

**Holotypus:** Northern Territory, South Magela Gorge, Kakadu National Park, 9 Nov. 2016, *K. Brennan 10717* (DNA D0273953).

*Hibbertia* sp. South Magela (*K.G. Brennan 896*) NT Herbarium in R.A.Kerrigan & Albr., *Checkl. N. Terr. Vasc. Pl.* [unnumbered page] (2007).

Pendulous or rarely prostrate much-branched *shrubs* with slender branches to 0.5 m long; young stems densely sericeous to villous with white simple hairs, older stems with persistent leaf scars. *Leaves* subsessile, ± spreading, obovate to elliptic, 5–12 (–15) mm long, 2–5 mm wide, ± discolorous; base attenuate, gradually tapering to a shallow insertion on the stem; margins entire, flat or slightly recurved; adaxial surface greenish, grooved along the midrib, densely to moderately pubescent with short, erect, ± semi-translucent simple hairs, becoming sericeous with longer and more appressed hairs near the base; abaxial surface whitish, midrib prominent and raised, densely sericeous with ± appressed simple hairs; apex obtuse and sometimes mucronate, with the midrib flush with the apex or continued as a point to c. 0.5 mm long. *Flowers* single, terminal on short branches, sessile, 10–15 mm in diameter; primary bract leaf-like, oblong, 4.2–4.8 mm long, 1.2–1.5 mm wide, densely hairy as for the leaves but with longer marginal hairs, acute; secondary bracts absent. *Sepals* unequal, adaxial surface glabrous or with appressed simple hairs below the apex, abaxial surface densely villous with white to slightly rust-coloured simple hairs, the margins ciliolate; outer sepals broadly obovate to broadly elliptic, 5.5–7 mm long, 3–3.5 mm wide, apex shortly acuminate (by folding of the apical margin); inner sepals ovate to elliptic, 5.2–6.5 mm long, 2.3–2.6 mm wide, acute to shortly acuminate (by folding of the apical margin). *Petals* yellow, obovate, 7–8.5 mm long, emarginate. *Stamens* c. 70, arranged around the carpels; filaments filiform, scarcely connate basally, 2–2.5 mm long; anthers obloid, 1.1–1.4 mm long, dehiscing by short, introrse, apical slits. *Staminodes* absent. *Carpels* 3; ovaries ovoid, glabrous; styles eccentrically attached below the ovary apex and curving outwards and then erect to place the stigmas above the stamens, 2.7–3 mm long. *Ovules* 5 per carpel. *Seeds* not seen. **Fig. 1.**

***Diagnostic features.*** *Hibbertia pendula* can be distinguished by the following combination of characters: a pendulous and cremnophilous shrub; leaves 5–12 (–15) mm long, 2–5 mm wide, discolorous, persistently hairy, adaxially green and densely to moderately pubescent with short and erect simple hairs, abaxially whitish and densely sericeous with appressed simple hairs; flowers sessile; sepals abaxially densely villous, whitish to slightly rust-coloured; stamens c. 70, arranged around the carpels, the anthers 1.1–1.4 mm long; carpels 3, glabrous.

***Phenology.*** Flowering specimens have been collected in November and May. It is also likely to flower between these months, like other *Hibbertia* species in the region.

***Distribution.*** The new species is only known from Magela Creek Gorge, c. 20 km SE of Jabiru near the eastern boundary of Kakadu National Park (N.P.). Most records are from within the National Park, but a couple occur just east of the park boundary in Western Arnhem Land.

***Habitat.*** Occurs in sandstone gorges hanging from fissures in cliff faces.

***Conservation status.*** *Hibbertia pendula* is listed as Vulnerable in the N.T. under the *Territory Parks and Wildlife Conservation Act 1976*.

***Etymology.*** From the Latin *pendulus* (hanging), referring to the typical habit of the species hanging from fissures in cliff faces.

***Proposed vernacular name.*** Magela Gorge guinea-flower.

***Notes.*** *Hibbertia pendula* is one of the few members of *H.* subg. *Hibbertia* in the N.T., the others being *H. glaberrima* and *H. scopulicola*. The similarities and differences of *H. pendula* to *H. scopulicola* are discussed below in the notes under the latter species. *Hibbertia glaberrima* can be readily distinguished from *H. pendula* by having pedicellate flowers and usually glabrous linear to elliptic leaves (15–) 35–55 (–75) mm long. *Hibbertia glaberrima* is only known from ranges in arid central Australia (N.T. and S.A.) and the Pilbara (W.A.).

*Hibbertia pendula* is similar to *H. kaputarensis* B.J.Conn and *H. acuminata* B.J.Conn, both of which are restricted to northern New South Wales (Conn 1990). The three species are similar in having numerous stamens (c. 70 in *H. pendula*, c. 40 in *H. acuminata* and up to c. 100 in *H. kaputarensis*) around 3 glabrous carpels and sepals that are abaxially hairy. While the sepal hairs in *H. pendula* are mostly whitish, with sometimes slightly rusty hairs at the base, the sepal hairs in *H. kaputarensis* are mostly rust-coloured throughout. The sepal hairs of *H. acuminata* are moderately hairy with whitish, long, and spreading hairs in the central region. Both *H. acuminata* and *H. kaputarensis* have sepal margins that are membranous and glabrous, except for marginal cilia. The sepal margins in *H. pendula* are covered by dense, long, straight hairs except at the very base of the sepal. The sepal apex in *H. acuminata* varies from *H. pendula* in being distinctly folded or keeled as to appear long-acuminate. The three species also differ in leaf indumentum, which is very dense and of different textures on the two leaf surfaces in *H. pendula* (described above), while the leaf indumentum is uniform on both surfaces and pubescent or villous in *H. acuminata* and tomentose (sometimes also glabrescent) in *H. kaputarensis*.

DNA
cm 0 1 2 3 4 5 6 7 8 9 10
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Northern Territory Government
NORTHERN TERRITORY HERBARIUM (DNA & NT)
AUSTRALIA
Hibbertia sp. South Magela (K.G.Brennan 896)
Sth Magela Gorge, Kakadu NP
STATE / DIST / IBRA:
NT / DG / ARP
12° 48' 21" S, 132° 59' 47" E
Flowers yellow. Shrub, hanging from vertical sandstone cliff face, in dissected sandstone, in gorge.
Brennan K. 10717
09 Nov 2016
DILLENIACEAE
DNA
D0273953
*D0273953*
Hibbertia pendula T.Hammer
Holotype
Det./Conf.:T.A. Hammer 3 June 2022

**Fig. 1.** Holotype of *Hibbertia pendula* T.Hammer, *K. Brennan 10717* (DNA D0273953).

*Hibbertia acuminata* and *H. kaputarensis* were split by Conn (1990) from the more widespread *H. obtusifolia* DC., which occurs from Victoria to Queensland. *Hibbertia obtusifolia* is less similar to *H. pendula* than either of these two species and can be easily separated from *H. pendula* by having nearly glabrous sepals (except marginal cilia) and fewer stamens (usually 30–40). The leaf indumentum of *H. obtusifolia* is similar to *H. kaputarensis*, being usually sparse and uniformly and shortly grey-tomentose. A dichotomous key for *Hibbertia*, including all species discussed above, can be found on KeyBase (https://keybase.rbg.vic.gov.au/keys/show/11717).

The habit and habitat of *H. pendula* differs from *H. acuminata*, *H. kaputarensis* and *H. obtusifolia* in being a typically pendulous shrub restricted to crevices of sandstone cliff faces, which is very distinctive within *Hibbertia*. Conn (1990: 290) described the habitat of *H. acuminata* as being "sandy to rocky soil overlying sandstone", which could indicate a shared geology with *H. pendula* of occurring in habitats rich with sandstone.

### *Additional specimens examined*

NORTHERN TERRITORY. 22 km SE of Jabiru Airstrip, 10 Apr. 1995, *K. Brennan & I.D. Cowie s.n.* (DNA); Gorge W of Magela Ck gorge, Kakadu N.P., 26 Aug. 2004, *I.D. Cowie & D.J. Liddle 10333* (DNA); Magela Ck gorge, Kakadu N.P., 5 Sep. 2016, *J. Westaway & B. Wirf 5172* (DNA); Magela Gorge, Kakadu N.P., 24 May 2016, *B. Wirf 1056* (DNA); South Magela Gorge, Kakadu N.P., 5 Sep. 2016, *B. Wirf 1126* (DNA).

### *Hibbertia scopulicola* T.Hammer, *sp. nov.*

**Holotypus:** Northern Territory, Wellington Range, 19 July 2009, *D.E. Murfet 6524* (AD234900). **Isotypus:** DNA.

*Hibbertia* sp. 7 (Mount Howship; *C.R.Dunlop 6656*) J.D.Briggs & J.H.Leigh, *Rare or Threat. Austral. Pl.* 50 (1996).

*Hibbertia* sp. Mount Howship (*C.R.Dunlop 6656*) NT Herbarium in R.A.Kerrigan & Albr., *Checkl. N. Terr. Vasc. Pl.* [unnumbered page] (2007).

Pendulous or spreading *shrubs* to 0.6 m long, branches to 1.2 m long; young stems moderately to densely pubescent to sericeous with appressed white simple hairs, older stems with persistent leaf scars. *Leaves* subsessile, ± spreading, elliptic to oblanceolate or obovate or narrowly elliptic to narrowly lanceolate, (10–) 20–40 (–50) mm long, (3–) 5–12 (–15) mm wide, ± concolorous; base attenuate, gradually tapering to a shallow insertion on the stem; margins entire, flat or slightly recurved; adaxial surface greenish, grooved along the midrib, glabrescent, very sparsely to sparsely pubescent with appressed white simple hairs or rarely sparsely to moderately villous with ± spreading white simple hairs; abaxial surface greenish, midrib prominent and raised, indumentum as for the adaxial surface; apex acute to obtuse, apiculate to cuspidate with the midrib continued to a point, 1–2 (–3) mm long. *Flowers* single, terminal on short branches, sessile, 15–25 mm in diameter; primary bract leaf-like, narrowly elliptic to linear, 5–7 mm long, c. 0.8–1.5 mm wide, indumentum as for the leaves, acute; secondary bracts absent. *Sepals* unequal, adaxial surface glabrous or with appressed simple hairs below the apex, abaxial surface sparsely to moderately sericeous with appressed simple hairs, the margins ciliolate; outer sepals narrowly elliptic to elliptic, 6.5–13 mm long, 3–3.5 mm wide, apex acute to acuminate (by folding of the apical margin); inner sepals ovate to broadly elliptic, 6–11 mm long, 3.5–4.5 mm wide, acute to shortly acuminate (by folding of the apical margin). *Petals* yellow, obovate, 8–12 mm long, emarginate. *Stamens* 40–60, arranged around the carpels; filaments filiform, scarcely connate basally, unequal, 1–1.5 (–2) mm long; anthers obloid, unequal, 1.5–2.5 (–3) mm long, dehiscing by short, introrse, apical slits. *Staminodes* absent. *Carpels* 3; ovaries ovoid, glabrous; styles eccentrically attached below the ovary apex and curving outwards and then erect to place the stigmas above the stamens, 2.5–3 mm long. *Ovules* 3 or 4 per carpel. *Seeds* obloid to slightly reniform, c. 2 mm long, glossy, dark brown; aril membranous, ± basal to covering ½ of seed, margins lobed, white to cream-coloured (dried). **Fig. 2 & 3.**

***Diagnostic features.*** *Hibbertia scopulicola* can be distinguished by the following combination of characters: a pendulous and cremnophilous shrub; leaves (10–) 20–40 (–50) mm long, (3–) 5–12 (–15) mm wide, ± concolorous, both surfaces green with sparse appressed simple hairs (rarely moderately dense with spreading hairs), glabrescent; flowers sessile; sepals abaxially sparsely to moderately sericeous with appressed, whitish hairs; stamens 40–60, arranged around the carpels, the anthers 1.5–2.5 (–3) mm long; carpels 3, glabrous, 3- or 4-ovulate.

***Phenology.*** Flowering specimens recorded from March, April, July and August.

***Distribution.*** Occurs in West Arnhem and Kakadu N.P., east of Jabiru, N.T. It is found from the Wellington Range (*D.E. Murfet 6524*), in the north, to Upper Deaf Adder Creek (*K. Brennan 7927*), in the south, and as far east as Upper Liverpool River (*K. Brennan 8003*).

***Habitat.*** Occurs in sandstone gorges hanging from fissures in cliff faces.

***Conservation status.*** The species is not conservation listed, but classified as Near Threatened (http://eflora.nt.gov.au; as *Hibbertia* sp. Mount Howship).

***Etymology.*** The epithet is from the Latin *scopulus* (cliff) and *-cola* (dweller), referring to the habitat of the species.

***Proposed vernacular name.*** Cliff guinea-flower.

***Notes.*** *Hibbertia scopulicola* has been considered to be quite close in morphology to *H. scandens* (Willd.)

0 1 2 3 4 5 6 7 8 9 10
cm
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State Herbarium of South Australia
AD
State Herbarium of South Australia
AD234900
Hibbertia scopulicola T.Hammer
Holotype
Det./Conf.: T.A. Hammer 3 June 2022
Ex STATE HERBARIUM OF SOUTH AUSTRALIA (AD)
Dilleniaceae / AD234900
Hibbertia
(Rock ledges)
det. D.E. Murfet, s.dat.
Northern Territory. Darwin & Gulf District.
Wellington Range outlier.
Coord. ex GPS 11°47′58″S, 133°06′25″E; precn 1
Occasional. Hanging and growing out of cracks and ledges on sandstone outcrop.
Open rounded shrubs to 1 m high and wide. Leaves light green both sides. Flowers bright yellow.
D.E. Murfet 6524
19 Jul 2009
Duplicates to: DNA
Databased in: ADHERB (jsteeleh; geoc.OK)
Field Det. Hibbertia sp rock ledges
GPS
Loc. 11°47'58"S 133°06'25"E Region NT dg
Wellington Range outlier.
Freq. Occasional
Habitat Hanging and growing out of cracks and ledges on sandstone outcrop.
Notes Open rounded shrubs to 1 metre high and wide. Leaves light green both sides. Flowers bright yellow.
Col. D.E.MURFET
Date 19/7/09 Number 6524

**Fig. 2.** Holotype of *Hibbertia scopulicola* T.Hammer, *D.E. Murfet 6524* (AD234900).

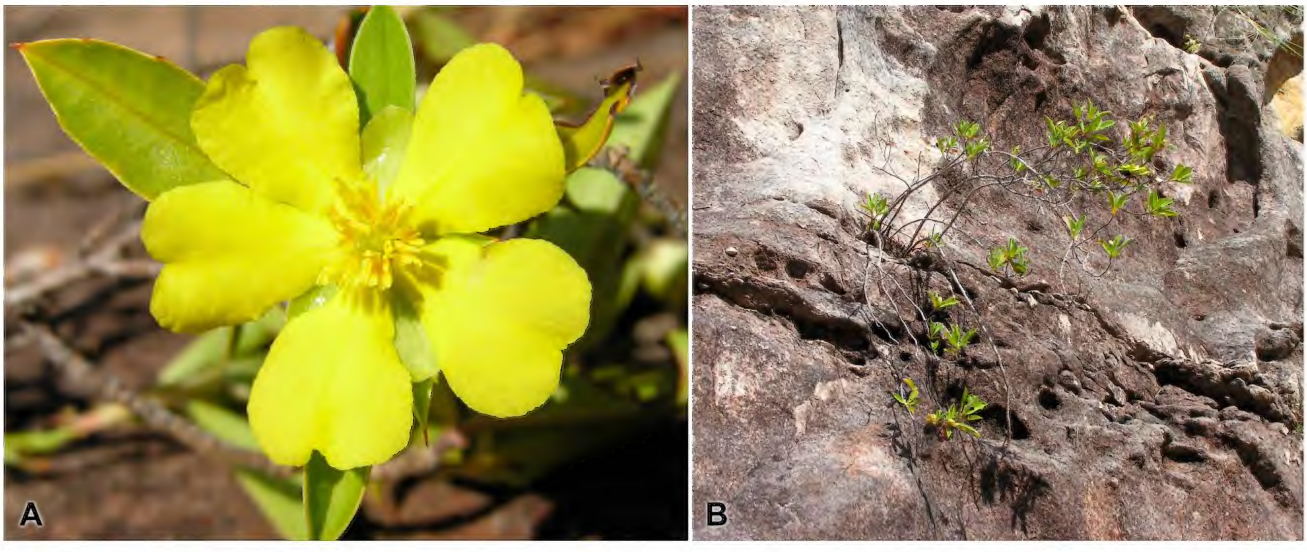


**Fig. 3.** *Hibbertia scopulicola* at the type locality, Wellington Range. **A** Flower; **B** plant growing on cliff face. — A, B *D.E. Murfet 6524* (AD). Photos by D.E. Murfet.

Dryand. by *Hibbertia* experts R.D. Hoogland and J.R. Wheeler, who determined the specimens *L.A. Craven 2408* (DNA) and *M. Lazarides 9005* (DNA), respectively, as *H. scandens*. *Hibbertia scandens* is quite variable but can be distinguished from *H. scopulicola* by being a twining climber that occurs in a variety of habitats, including on beach dunes, in rainforests and wet sclerophyll forests, but not growing pendulous in the fissures of sandstone cliff faces. Flowers of *H. scandens* are c. 4–6 cm in diameter (cf. 1.5–2.5 cm in diameter in *H. scopulicola*) and have short pedicels 2–6 (–15) mm long (cf. sessile flowers), 3–5 (–7) carpels (cf. 3 carpels), usually more than 100 stamens (cf. 40–60 stamens) and with anthers 3–4.5 mm long (cf. 1.5–2.5 (–3)). The seeds of *H. scandens* have a distinctive bright, red–orange, fleshy aril that encloses the entire seed; in older dried specimens the aril is often yellowish in colour. The arils of *H. scopulicola* are mostly restricted to the base of the seed, but occasionally cover up to ½ of the seed, have lobed margins, and are white to cream-coloured in dried specimens.

Within the N.T., *H. scopulicola* is most similar to *H. pendula*, with which it shares the habitat and habit, i.e. both are pendulous shrubs occurring on sandstone cliffs. In sterile specimens, *H. scopulicola* can be readily distinguished from *H. pendula* by having leaves (10–) 20–40 (–50) mm long and (3–) 5–12 (–15) mm wide (cf. 5–12 (–15) mm long and 2–5 mm wide in *H. pendula*), a leaf apex that is apiculate to cuspidate (cf. apex rounded or occasionally mucronate), and a leaf indumentum that is usually sparsely appressed-hairy on both surfaces. *Hibbertia pendula* has a much denser indumentum throughout the plant and has different textures of hairs on the leaf surfaces, being erect-pubescent with short semi-translucent hairs adaxially and appressed-sericeous with white hairs abaxially.

There are additional floral characters to distinguish *H. pendula* from *H. scopulicola*. Most specimens of *H. scopulicola* have outer sepals that are distinctly narrower than the inner sepals, while *H. pendula* has outer sepals that are wider than the inner sepals. Despite *H. scopulicola* consistently having larger flowers (15–25 mm in diameter) than *H. pendula* (10–15 mm in diameter), *H. scopulicola* has fewer stamens (40–60) than *H. pendula* (c. 70) in the specimens examined. Though there are fewer stamens in the flowers of *H. scopulicola*, the anthers are consistently longer (1.5–2.5 (–3) mm long), than those of *H. pendula* (1.1–1.4 mm long).

While *H. scopulicola* is typically very sparsely to sparsely hairy with short appressed hairs, the specimen *K.G. Brennan 7927* is more unusual in having spreading-villous hairs. This specimen can nevertheless be readily segregated from *H. pendula* by the leaves being concolorous, > 15 mm long, having the same indumentum type on both sides of the leaves, and a long-apiculate apex to c. 2 mm long. The flowers and anthers of *K.G. Brennan 7927* have lengths that are typical for *H. scopulicola*.

### *Additional specimens examined*

NORTHERN TERRITORY. Upper Deaf Adder Ck, escarpment opposite Kakadu Fire Plot 064, 20 Mar. 2009, *K.G. Brennan 7927* (DNA); upper Liverpool River, Mirbik area, 21 Apr. 2009, *K.G. Brennan 8003* (DNA); above fire plot 062, Deaf Adder, Kakadu N.P., 12 Mar. 2014, *K. Brennan 10268* (DNA); sandstone bluff, East Alligator area, 25 Feb. 1973, *L.A Craven 2408* (DNA); Hill 253, Northern Outliers, Kakadu, 21 Feb. 2005, *J.L. Egan & J. Russell-Smith 5572* (DNA); 11.5 km NE of Jabiru East, Kakadu N.P., 26 May 1980, *M. Lazarides 9005* (DNA); 10 km SE of Mt Howship, 30 Oct. 1987, *Russell-Smith 3892 & Lucas* (DNA); Upper Magela Ck area, Western Arnhem Land, 24 Apr. 2007, *J. Westaway 2276* (AD, DNA); Kakadu, northern sandstone outlier, 12.6 km NE of Jabiru airfield western heli[pad], 10 Aug. 2015, *B. Wirf 930 & T. North* (DNA); Kakadu, northern sandstone outlier, 12.6 km NE of Jabiru airfield, western heli[pad], 12 Aug. 2015, *B. Wirf 946 & T. North* (DNA).

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# A taxonomic update of *Stenanthera* (Ericaceae: Epacridoideae: Styphelieae), including description of a third species from Western Australia, an updated description of *S. pungens* and an Australia-wide key to species

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**Abstract:** A new Western Australian species, *Stenanthera lacsalaria* A.J.G.Wilson & Hislop is described and illustrated. An updated description of *S. pungens* (Keighery) Hislop and a key to all members of the genus are also provided.

**Keywords:** Ericaceae, Epacridaceae, *Stenanthera*, Western Australia, new species

## Introduction

*Stenanthera* R.Br. was originally described by Robert Brown (1810) to accommodate *S. pinifolia* R.Br. Of the five species that were added to the genus between 1810 and Bentham's *Flora Australiensis* (1868), only *S. conostephioides* Sond. has proven to be congeneric with *S. pinifolia*. The others are now recognised as belonging either to *Brachyloma* Sond. (current names: *B. baxteri* (DC.) Puente-Lel., *B. ericoides* (Schltdl.) Sond., *B. geissoloma* (F.Muell.) Cranfield) or *Styphelia* Sm. (current name: *S. discolor* (Sond.) Hislop, Crayn & Puente-Lel.). Bentham himself did not accept *Stenanthera* at the generic level, instead treating it as a section under *Astroloma* R.Br. Because *S. pinifolia* lacks corolla tube appendages, while they are present in *S. conostephioides*, they were not even placed in the same section by Bentham.

*Stenanthera* was eventually reinstated as one of the findings of a recent study into the molecular phylogeny of the tribe Styphelieae Bartl. (Puente-Lelièvre *et al.* 2016). The relevant topology in the published phylogenetic tree showed a well-supported sister relationship between *Stenanthera* and *Conostephium* Benth. A morphological comparison between these two genera is given in an earlier paper (Hislop 2016).

The south-eastern and south-western Australian species of *Stenanthera* present an interesting contrast in terms of the extent and pattern of their distributions. While *S. pinifolia* and *S. conostephioides* are both common and widespread over large areas of south-eastern Australia (including Tasmania in the case of the former), the three western species have very much more restricted distributions. At this stage, *S. pungens* (Keighery) Hislop and the recently described *S. localis* Hislop (Hislop 2020) are only known from single populations, while *S. lacsalaria* A.J.G. Wilson & Hislop, described below, is currently known from six.

Although it is the last Western Australian member of the genus to be formally described, *Stenanthera lacsalaria* was the first to be recognised as an unnamed taxon when the phrase-name *Astroloma* sp. Grass Patch (*A.J.G. Wilson 110*) was added to the Western Australian Plant Census in 1992. The first to be described, *S. pungens* (Keighery) Hislop was published as a species of *Conostephium* in Keighery (2002) before being transferred to *Stenanthera* (Hislop 2016). However, the protologue for that species was rather scant and an updated description is included here to allow a full morphological comparison of the three western species.

## Methods

This study was based on an examination of dried specimens housed at the Western Australian Herbarium, together with field observations of the species described.

Foliar measurements and observations were taken from dried specimens in natural posture. Care was taken to confine observations to mature leaves. Leaf lamina length is inclusive of the mucro. A separate measurement for the mucro is also given. Floral measurements were taken from rehydrated flowers in natural posture, with the exception of the corolla lobes, which were uncurled to their fullest length before measuring. The width of floral bracts, bracteoles and sepals was also obtained from rehydrated flowers in


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natural posture, i.e. they were not flattened out before measurement. This method was preferred because their curvature is so extreme that they are inclined to split or become pleated when attempts are made to flatten them. However, it should be noted that measurements obtained by this method are inherently imprecise.

Bioregions referred to in the text follow *Interim Biogeographic Regionalisation for Australia* (IBRA) v. 7 (Department of the Environment 2013).

## Taxonomy

### 1. *Stenanthera lacsalaria* A.J.G.Wilson & Hislop, *sp. nov.*

**Holotypus:** Scaddan area [precise locality withheld for conservation reasons], Western Australia, 9 May 2012, *M. Hislop 4190* (PERTH08366330). **Isotypi:** CANB, K, MEL, NSW.

*Astroloma* sp. Grass Patch (*A.J.G. Wilson 110*) Western Australian Herbarium in *FloraBase*, https://florabase.dpaw.wa.gov.au/ [accessed 3 May 2022].

Compact and sometimes spreading *shrubs* to c. 1 m high and 1.2 m wide, multi-stemmed at ground and probably with a fire-tolerant rootstock. Young *branchlets* with a dense, often rather matted indumentum of mostly incurved hairs, shallowly retrorse to steeply antrorse, to c. 1.2 mm long. *Leaves* antrorse, usually steeply so; apex long-mucronate, pungent, the mucro ± straight to slightly inflexed, 0.8–1.6 mm long; base attenuate; petiole well-defined, 1–1.6 mm long, hairy on all surfaces, or the abaxial surface glabrescent, often with a white excrescence on young growth; lamina linear, 9–22 mm long, 0.8–1.7 mm wide, 3-veined (the midvein broader than the two laterals), adaxially convex, the margins revolute usually concealing the entire abaxial surface apart from the midvein (or sometimes also concealing the midvein), longitudinal axis gently incurved to gently recurved; surfaces markedly discolorous; adaxial surface and revolute margins of the abaxial surface shiny, rugulose, with a moderately dense indumentum of short, coarse, antrorse hairs; remainder of abaxial surface (i.e. excluding the recurved margins) much paler, usually only the glabrous or sparsely hairy outer surface of the midvein evident, with 2 deep grooves between the recurved margins and the midvein; where the grooves are not tightly closed the shortly hairy, lateral surfaces of the veins are exposed. *Inflorescence* axillary, erect, sessile. *Floral bracts* 7–10, ovate to broadly ovate, 1–10 mm long, 1–5.0 mm wide, obtuse to subacute, at least the upper ones mucronulate, pink to red. *Bracteoles* narrowly ovate, 8.2–12 mm long, 3–5 mm wide, acute, mucronate; abaxial surface usually hairy in the upper ½–⅔, glabrous below, or occasionally ± glabrous throughout, pink to red, multi-veined but ± smooth (not striate); adaxial surface glabrous; margins ciliate in the upper half with hairs to 0.4 mm long. *Sepals* narrowly ovate to narrowly elliptic, 11–15 mm long, 2.5–4 mm wide, acute and mucronate; abaxial surface usually hairy in the upper ½–⅔, glabrous below, or occasionally ± glabrous throughout, pink to red, multi-veined but ± smooth (not striate); adaxial surface glabrous; margins ± glabrous or irregularly ciliate towards the apex, with hairs to 0.4 mm long. *Corolla tube* narrowly obovoid to narrowly ellipsoid, red or orange-red, becoming paler in the lower half, shorter than the sepals, 8.5–11.5 mm long, 4.5–6 mm wide; outer surface glabrous in basal ⅔–¾, sparsely hairy above, or ± glabrous throughout; inner surface with 5 decurrent, transversely aligned appendages close to the base; the free portion of the appendages 0.6–1 mm long, ± flat, variously orientated from retrorse to antrorse, densely hairy on the upper surface, with hairs to c. 0.8 mm long, more sparsely hairy on the lower surface; the remainder of the inner tube surface with scattered hairs. *Corolla lobes* red to orange-red, erect basally,

### Key to species of *Stenanthera*

**1.** Inflorescence erect

- **2.** Corolla tube various shades of yellow, red and green, the lobes green; appendages absent from inner surface of the corolla tube (N.S.W., Tas., Vic.) . . . . . ***S. pinifolia***
- **2:** Corolla red or orange-red throughout; 5 hairy appendages present towards the base of the inner surface of corolla tube (W.A.: N and NE of Esperance) . . . . . 1. ***S. lacsalaria***

**1:** Inflorescence pendulous

- **3.** Mature leaves with 5–7 (9) veins (several veins usually visible in situ), the mid-vein 0.08–0.2 mm wide, not or scarcely wider than the others, raised or not; basal corolla tube appendages longitudinally aligned, ridge-like (S.A., Vic.) . . . . . ***S. conostephioides***
- **3:** Mature leaves with 3 veins (only 1 visible in situ, the other two completely concealed within the revolute margins), the mid-vein 0.3–0.4 mm wide, manifestly wider than the two laterals, always strongly raised; basal corolla tube appendages transversely aligned
  - **4.** Anthers 3–3.5 mm long; style 18.8–22 mm long; sepals long-ciliate, the hairs 0.5–1 mm long; petiole 0.5–1 mm long, hairy (W.A.: restricted distribution, E of Pingrup) . . . . . 2. ***S. pungens***
  - **4:** Anthers 1.7–2.2 mm long; style 13–15.5 mm long; sepals ciliolate, the hairs to c. 0.1 mm long; petioles 1.2–1.6 mm long, glabrous (W.A.: restricted distribution, Cascade area) . . . . . ***S. localis***

spreading slightly in the upper ¼–⅓, (5.5–) 6.2–8 mm long, 2.2–2.8 mm wide, shorter than the tube; outer surface with a moderately dense indumentum of mostly antrorse hairs throughout, or rarely sparse towards the apex; inner surface with scattered hairs in the lower half, a dense zone of straight, ornamented hairs in the central portion and then papillose towards the tips. *Filaments* distinctly flattened, glabrous, 1.5–2.3 mm long, 1–1.4 mm wide, adnate to the tube just below the sinuses, attached ⅔–¾ above anther base. *Anthers* white, 2–2.5 mm long, slightly exserted from the corolla tube, apex shallowly emarginate. *Nectary* annular, 0.4–0.5 mm long, shallowly and irregularly lobed, sparsely and minutely hairy about the rim. *Ovary* globose to depressed-globose, 1.2–1.5 mm long, 1.3–1.6 mm wide, glabrous or with a few hairs at the apex, 5-locular. *Style* 12–17 mm long, minutely scabrous in the upper half, glabrous below, abruptly differentiated from the ovary apex, exserted beyond the corolla tube and the erect corolla lobe bases; stigma expanded. *Fruit* much shorter than the sepals, ovoid to ellipsoid, 6–6.5 mm long and 4–5 mm wide, circular in transverse section; surface glabrous, with shallow longitudinal grooves when dry (a thin mesocarp is apparent upon rehydration); apex obtuse to subacute. **Fig. 1.**

***Diagnostic characters.*** *Stenanthera lacsalaria* is readily distinguished from the other western members of the genus by its erect, sessile inflorescence and white anthers.

***Distribution & habitat.*** *Stenanthera lacsalaria* occurs in the Mallee bioregion of Western Australia with most collections from a restricted area north and north-east of Esperance and one from north-west of the town. It grows in close proximity to salt lakes and saline drainage lines in heath or open woodland. Species that have been recorded growing in association include *Callitris columellaris*, *Melaleuca thyoides*, *M. hnatiukii*, *Kunzea salina*, *Leucopogon canaliculatus* and *Hypolaena fastigiata*.

***Phenology.*** Apparently has an extended flowering period between late autumn and early spring, probably with a peak between May and July. Fruiting collections have been made in October and November.

***Etymology.*** From the Latin *lacus* (lake), *salsus* (salty) and *-arius* (pertaining to), a reference to the preferred habitat of the species.

***Conservation status.*** Conservation Codes for Western Australian Flora: Priority Two (Smith & Jones 2018). Currently known from six populations, two of which are in nature reserves. Because of the myriad salt lakes in remote and inaccessible country to the north-east of Esperance it seems likely that new populations of this species will come to light over time.

***Affinities.*** *Stenanthera lacsalaria* is distinguished most obviously from its Western Australian congeners by its erect (rather than pendulous), sessile (rather than with an obvious axis) inflorescence and in having white rather than yellow anthers. It further differs from *S. localis*, the species to which it is closest geographically, in its hairy (rather than glabrous) petioles, manifestly hairy adaxial leaf surfaces (*cf.* ± glabrous or with a very sparse indumentum of short, antrorse hairs) and relatively long corolla lobes ((5.5–) 6.2–8 mm long *cf.* 4–5.2 mm in *S. localis*).

**Fig. 1.** *Stenanthera lacsalaria*. Flowering branchlet. Scale bar = 1 cm. — Drawing by Hung Ky Nguyen.

*Stenanthera pinifolia* R.Br. from eastern Australia also has an erect inflorescence but lacks the corolla tube appendages of *S. lacsalaria*. And whereas in the new species the corolla is entirely red, or orange-red, in *S. pinifolia* it consists of two or three contrasting colours, apparently with different colour combinations in different parts of the species' range. In Tasmania and central Victoria the corolla tube is yellow and the lobes green, but in New South Wales and eastern Victoria the tube is red grading to yellow towards the base of the lobes and the lobes themselves are green.

### *Other specimens examined*

WESTERN AUSTRALIA. [Localities withheld for conservation reasons] Oct. 1984, *M.A. Burgman 4350* (PERTH); 29 June 2006, *R. Davis 11077* (PERTH); 21 May 2004, *M. Hislop & F. Hort MH 3215* (CANB, CNS, NSW, PERTH); 9 May 2012, *M. Hislop 4191* (CANB, K); 8 Nov. 2009, *O. Massenbauer OM 4* (PERTH); 10 Sep. 1984, *P. van der Moezel 449* (PERTH); 22 June 1990, *P. van der Moezel 506*

(PERTH); 7 Sep. 1995, *D. Papenfus DP 142* (PERTH); 8 Oct. 2007, *J.A. Wege & R. Butcher JAW 1415* (CANB, PERTH); 9 June 1988, *A.J.G. Wilson 110* (PERTH); 9 June 1988, *A.J.G. Wilson 111* (PERTH); 20 Sep. 1988, *A.J.G. Wilson 174* (PERTH).

### 2. *Stenanthera pungens* (Keighery) Hislop

*Nuytsia* 27: 285 (2016). — *Conostephium pungens* Keighery, *Nordic J. Bot.* 22: 50–51 (2002). — **Holotype:** East of Nyabing [precise locality withheld for conservation reasons], Western Australia, 4 May 1999, *G.J. Keighery & N. Gibson 4967* (PERTH 06823475). **Isotype:** CANB.

Erect *shrubs* to c. 1.7 m high and 2 m wide, but most mature plants c. 1.5 m high and 1.5 m wide, apparently with a fire-sensitive rootstock. Young *branchlets* with a dense, variable indumentum of curved, variously orientated hairs (from shallowly antrorse to strongly retrorse), to c. 0.4 mm long. *Leaves* spreading, from shallowly retrorse to steeply antrorse; apex long-mucronate, pungent, the mucro ± straight to slightly inflexed, 0.5–1 mm long; base attenuate to cuneate; petiole well-defined, 0.5–1 mm long, hairy on all surfaces, often with a white excrescence on young growth; lamina linear, 9–16 mm long, 0.8–1 mm wide, 3-veined (the midvein broader than the two laterals), adaxially convex, the margins revolute usually concealing the entire abaxial surface apart from the midvein (or sometimes also concealing the midvein), longitudinal axis gently incurved to gently recurved; surfaces markedly discolorous; adaxial surface and revolute margins of the abaxial surface shiny, rugulose, with a sparse to moderately dense indumentum of short, coarse antrorse hairs; remainder of abaxial surface (i.e. excluding the recurved margins) much paler, usually only the ± glabrous outer surface of the midvein evident, with 2 deep grooves between the recurved margins and the midvein; where the grooves are not tightly closed the shortly hairy, lateral surfaces of the veins are exposed. *Inflorescence* axillary, pendulous; axis 2–2.6 mm long, hairy, but surface in part obscured by imbricate bracts. *Axis bracts* 7–10, depressed-ovate to broadly ovate. *Floral bracts* 4–5, ovate to elliptic, 3.2–12 mm long, 2.5–4.5 mm wide, obtuse, not mucronate, red in the upper half. *Bracteoles* narrowly ovate, 10.2–13.0 mm long, 3.5–5 mm wide, obtuse, not or scarcely mucronate; abaxial surface minutely antrorse-hairy towards the apex and glabrous below or ± glabrous throughout, red in the upper half, multi-veined but ± smooth (not striate); adaxial surface glabrous; margins densely ciliate with hairs 0.2–0.5 mm long. *Sepals* narrowly ovate to narrowly elliptic, 16–18 mm long, 3.5–5.5 mm wide, acute, mucronate; abaxial surface shortly antrorse-hairy in the upper half, glabrous below, red in the upper half, multi-veined but ± smooth (not striate); adaxial surface glabrous; margins densely ciliate with hairs 0.5–1 mm long. *Corolla tube* narrowly ellipsoid to narrowly obovoid, exposed portion red, shorter than the sepals, 13–16.8 mm long, 5–7.5 mm wide; outer surface glabrous in basal ⅔–¾, sparsely hairy above; inner surface with 5 decurrent, transversely aligned appendages close to the base; the free portion of the appendages 1.9–2.3 mm long, flat, deflexed, hairy on the margins and upper surfaces with hairs to c. 1.2 mm long; the remainder of the inner tube surface with a few scattered hairs, mostly about the decurrent lines extending above the appendage bases. *Corolla lobes* red, erect basally, spreading to ± recurved in the upper ¼, 5–6.8 mm long, 2.8–3.8 mm wide, much shorter than the tube; outer surface with a dense indumentum of antrorse hairs throughout, the hairs becoming shorter towards the apex; inner surface with scattered hairs in the lower half, a dense zone of straight, ornamented hairs in the central portion and then papillose towards the tips. *Filaments* distinctly flattened, glabrous, 3–3.5 mm long, 1.2–1.4 mm wide, adnate to the tube just below the sinuses, attached ⅔–¾ above anther base. *Anthers* yellow, 3–3.5 mm long, barely exserted from the corolla tube, apex emarginate. *Nectary* annular, c. 0.5 mm long, ± truncate, glabrous. *Ovary* depressed-globose, 1.5–1.6 mm long, 1.8–1.9 mm wide, glabrous, 5-locular. *Style* 18.8–22 mm long, minutely scabrous towards the apex, glabrous below, abruptly differentiated from the ovary apex, exserted beyond the corolla tube and the erect corolla lobe bases; stigma slightly expanded. *Fruit* much shorter than the sepals, ovoid, c. 7 mm long and 5 mm wide (measurements based on very limited material), circular in transverse section; surface glabrous, with shallow longitudinal grooves when dry (a thin mesocarp is apparent upon rehydration); apex subacute.

***Illustration:*** M. Hislop, *Nuytsia* 31: 273, Figure 1: C, D (2020).

***Diagnostic characters.*** *Stenanthera pungens* can be distinguished from the other western members of the genus by the following character combination: growth habit relatively tall and spreading (to about 1.7 m high and 2 m wide); petiole 0.5–1 mm long, hairy on all surfaces; inflorescence pendulous; sepal margins long-ciliate with hairs 0.5–1 mm long; outer surfaces of corolla lobes hairy throughout; anthers yellow, 3–3.5 mm long; style 18.8–22 mm long.

***Distribution & habitat.*** *Stenanthera pungens* is only known from a small area east of Pingrup at the western end of the Mallee bioregion. It occurs on white sand dunes in proximity to a large salt lake, growing in heath or open mallee woodland. Associated species include *Eucalyptus incrassata*, *Eremaea pauciflora*, *Banksia baueri*, *Conostephium roei*, *Leptospermum erubescens* and *Adenanthos cygnorum*.

***Phenology.*** Flowering collections have been made in May and June and the only fruiting specimen was collected in October.

***Conservation status.*** Conservation Codes for Western Australian Flora: Priority Two (Smith & Jones 2018). Known only from one large population within a nature reserve.

***Notes.*** In the protologue (Keighery 2002) *Conostephium pungens* was described as occurring on gypsum dunes, and this information was repeated in the short communication transferring the species to *Stenanthera* (Hislop 2016). However, it is now accepted that the dunes in question are composed mostly of coarse sand rather than gypsum (M. Lyons, pers. comm.).

The first collection of this species was made by Ferdinand von Mueller in 1879. If the locality statement that accompanied this specimen, '100 miles north of the Stirling Range', is accurate it would place it about 60 km to the north of the single known population of the species. After Mueller it was another 120 years before the plant was collected a second time.

### *Other specimens examined*

WESTERN AUSTRALIA. [Localities withheld for conservation reasons] 24 May 2004, *M. Hislop & F. Hort MH 3236* (CANB, NSW, PERTH); 12 June 2017, *M. Hislop 4708* (CANB, MEL, PERTH); 12 June 2017, *M. Hislop 4709* (PERTH); 14 Oct. 1999, *G.J. Keighery & N. Gibson 6786* (PERTH); 1879, *F. Mueller s.n.* (MEL).

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# Australian species of Rhamnaceae published by Turczaninow, their types, current names and synonyms

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**Abstract:** The typification of eight names of Australian taxa of Rhamnaceae published by Turczaninow is clarified. Of these, five names (*Cryptandra cordata* Turcz., *C. microcephala* Turcz., *C. villosa* Turcz., *Trymalium oligocephalum* Turcz., *T. polycephalum* Turcz.) are basionyms of currently accepted names, two (*C. pauciflora* Turcz., *T. thomasioides* Turcz.) are heterotypic synonyms of other species names, and one name (*C. parvifolia* Turcz.) is an illegitimate later homonym of an earlier validly published name. Holotypes or lectotypes of these names can be found in Turczaninow's personal herbarium (KW-TURCZ) at the National Herbarium of Ukraine (KW). Lectotypes are also designated here for the following names published by other botanists: *Spyridium denticuliferum* Diels, *S. kalganense* Diels, *S. subochreatum* var. *laxiusculum* J.M.Black, *Pomaderris hirsuta* Steud., *T. behrii* F.Muell. ex Reissek and *T. subochreatum* F.Muell. Modern descriptions, notes and illustrations are provided for all eight taxa treated in this paper: *C. minutifolia* Rye var. *minutifolia*, *S. cordatum* (Turcz.) Benth., *S. microcephalum* (Turcz.) Benth., *S. oligocephalum* (Turcz.) Benth., *S. polycephalum* (Turcz.) Rye, *S. spadiceum* (Fenzl) Benth., *S. subochreatum* (F.Muell.) Reissek and *S. villosum* (Turcz.) Benth.

**Keywords:** Rhamnaceae, Pomaderreae, *Cryptandra*, *Spyridium*, Australia, Western Australia, South Australia, Victoria, typification, nomenclature

## Introduction

Nicolai Turczaninow (1796–1863; also sometimes transliterated as Turczaninov, Turtschaninoff, Turchaninov, etc.) is a well-known 19th century botanist and taxonomist, who published names for a considerable number of Australian taxa (Marchant 1990). During his lifetime he amassed a large herbarium through purchase and exchange. The history of his collection has been briefly described by Mosyakin *et al.* (2019) and Mosyakin & de Lange (2019) (and references therein); it is currently housed as a separate collection (KW-TURCZ) at the National Herbarium of Ukraine (KW).

Eight species names of Australian Rhamnaceae were published by Turczaninow in one publication, namely in Part 2/2 of his *Animadversiones* series of papers (Turczaninow 1858), published between 19 September 1858 and 28 October 1858 (see details in Marchant 1990 and Mosyakin & Alford 2022). It is now generally agreed that "new taxa described by Turczaninow in *Animadversiones* were based, unless noted otherwise, on specimens from his personal herbarium" (Mosyakin & de Lange 2019: 169) and that "if there is just one corresponding specimen in KW-TURCZ, that specimen should be considered the holotype and that type designation is final (Art. 9.1 of the ICN)" (Mosyakin *et al.* 2019: 382).

Typifications of the names in this paper follow the guidelines of McNeill (2014) and Mosyakin *et al.* (2019). In the case of Rhamnaceae names published by Turczaninow and discussed below, in all but one case, he mentions only one collection and there is only one corresponding specimen at KW-TURCZ. When he indicated more than one specimen then the one listed in Marchant (1990) is regarded here to be the lectotype of the name, i.e. Marchant's use of the term "type" in his table of Turczaninow type specimens, as well as his statement in the text that the table lists "holotype specimens" of Australian taxa described by Turczaninow, is interpreted as an inadvertent lectotypification and is here corrected to "lectotype" (Art. 9.10; Turland *et al.* 2018).


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All these names are based on specimens gathered by James Drummond in Western Australia (W.A.), mainly from his 5th collection from 1849 (Granite rocks or Mullean, i.e. Mts Stirling & Caroline, Stirling Range, Pallinup, Mt Barren Range, Cape Riche) and also his 4th collection with George Maxwell in 1847 (Albany, Stirling, Porongurups, Mt Manypeaks, Cape Riche, West Mt Barren, Moore River area) (Barker 2004).

While the KW-TURCZ specimens are generally the holotypes of these names, the status of the original material in other herbaria is not always clear, as Drummond did not use collecting numbers in the way they are generally used today (his numbers are more "taxon numbers"). In the past, specimens with the same number have been treated as isotypes and this practice is followed here. Drummond collections are distributed in many herbaria around the world.

Of these type specimens, JK and FU studied material from Australian herbaria, K and BM; SLM examined material at KW. Other type specimens were searched for and viewed online, either via aggregator websites (AVH, GBIF, JACQ, JSTOR Global Plants) or individual herbarium databases (A, BM, B, BR, CGE, E, FI, G, GH, K, KW, L, LD, LE, MEL, MO, NSW, NY, OXF, P, S, TCD, W; Barker 2004; see also Paul & Kellermann 2022: App. 2). However, few herbaria are fully digitised and available online, hence it is possible that some specimens have been missed. Herbarium acronyms follow Thiers (2008–).

Of the eight Turczaninow names discussed here, five are basionyms of currently accepted names, two are synonyms of other species, and one species-rank name was replaced by Rye (1995), as Turczaninow's name was an illegitimate later homonym of an earlier validly published name. In this paper we clarify the typification of these names, and provide concise current descriptions of the taxa, as well as some additional information. For most taxa, these are the first English language descriptions published since Bentham (1863); a recent detailed description of *Cryptandra minutifolia* subsp. *minutifolia* was published in Rye (1995b, 2007) and of *Spyridium subochreatum* in Walsh (1999). Identification keys to Rhamnaceae species in Western Australia can be found in Rye (2007), amended by Rye & Hislop (2020), for *Cryptandra* and Rye (1996), amended by Kellermann & Clowes (2022), for *Spyridium*.

## Taxonomy

### *Cryptandra minutifolia* Rye var. *minutifolia*

*Nuytsia* 10: 273 (1995). — *Cryptandra parvifolia* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 459 (1858), *nom illeg.*, *non Cryptandra parvifolia* (Hook.) Hook.f., *Bot. Antarct. Voy. III. (Fl. Tasman.)* 1: 73 (1855). — **Type citation:** "Nova Hollandia, Drum. IV. n. 156.". **Holotype:** Nova Hollandia, *J. Drummond 4: 156* ["*Drum IV n 156*"] (KW001001109) (Fig. 1). **Isotypes:** W.A., *J. Dr.*[*ummond*] *156* (MEL1618192); Swan River, *Drummond 4th 156 (4th coll^n)* (K001096723, ex Herb. Benth.); Swan R., *J. Drummond, 4th ser. No. 156* (K001096722, ex Herb. W.W. Saunders); Western Australia, 1847 [1840], *James Drummond, 4th collection No. 156* (PERTH01599313, ex BM); W. Australia, 1848, *Drummond 4th Coll. 156* (NSW654932, ex BM, received 20 Jan. 1915).

Evergreen *shrubs*, 0.2–0.6 (–0.9) m high, not spinescent; young stems with intertwined densely woolly-pubescent curved flexuose hairs over dense stellate hairs, soon ± glabrous. *Leaves* fasciculate: *stipules* c. 1–2.5 mm long, narrowly triangular to ovate, connate around the base of the petiole, with hairs on the adaxial (inner) surface; *petiole* 0.2–0.3 mm long (but leaves appearing sessile); *lamina* narrowly elliptic or elliptic, entire, 0.8–1.7 mm long, 0.6–0.8 mm wide, base obtuse, margins strongly revolute, apex strongly recurved, obtuse or apiculate, glabrous or tuberculate above. *Conflorescence* a terminal cluster or spike-like, of 2–5 axillary flowers; *bracts* broadly ovate to oblong-elliptic, 2.5–3.5 mm long. *Flowers* white; *pedicels* 0.5–1 mm long. *Hypanthium tube* 1–2.8 mm long, c. 2–3 mm diameter, glabrous, pubescent towards top. *Sepals* 2.7–3.5 mm long, erect or spreading, with an indumentum of dense stellate and closely appressed simple hairs, especially towards apex. *Petals* cucullate, c. 1.1 mm long, distinctly clawed. *Stamens* 1–1.2 mm long. *Disc* inconspicuous, densely pubescent. *Ovary* semi-inferior; roof stellate-pubescent; *style* 2.5–3.6 mm long, glabrous, base densely hairy. *Fruit* ellipsoid, 2.3–2.5 mm long, brown; torus in the middle third. *Seeds* c. 1.7 mm long; *aril* whitish.

***Illustrations:*** B.L. Rye, *Nuytsia* 10: 266, Fig. 3L–N (1995); B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 603 (1998).

***Distribution & habitat.*** The taxon is endemic to W.A., where it grows from Manmanning east to Chiddarcooping Hill and south-east to the Ravensthorpe Range, on plains, in mallee or shrubland vegetation on sandy or clayey soils, sometimes with laterite.

***Phenology.*** Flowers: June–Oct.; fruits: Sep.–Nov.

***Note.*** When Turczaninow published *Cryptandra parvifolia*, he created a later homonym and thus an illegitimate name, as *C. parvifolia* (Hook.) Hook.f. [current name: *Spyridium parvifolium* (Hook.) Benth.] had been published a few years earlier. Rye (1995) published the replacement name *C. minutifolia* for Turczaninow's taxon.

The typical subspecies differs from *C. minutifolia* subsp. *brevistyla* Rye in its longer style, fewer flowers per conflorescence, and shorter sepals and hypanthium tube. The indumentum on the sepals tends to have shorter simple hairs in subsp. *minutifolia*. *Cryptandra minutifolia* is closely related to *C. beverleyensis* Rye, which tends to have less hairy flowers.

**Fig. 1.** Holotype of *Cryptandra parvifolia* Turcz., current name *C. minutifolia* Rye var. *minutifolia* (KW001001109).

***Etymology.*** From the Latin *minutus* (small) and *folium* (leaf), referring to the small leaves of the taxon.

### *Selected specimens examined*

WESTERN AUSTRALIA. Halfway between Newdegate and Lake Grace, 10 Aug. 1963, *A.M. Ashby 206* (AD); Old Newdegate Rd, edge of Lake King Reserve (Res.), 5 Sep. 2010, *G. Byrne 3952* (PERTH); Dragon Rocks Nature Res. No. 36128, E boundary, N of Pingaring-Varley Rd, 22 Aug. 1991, *A.M. Coates 2590* (AD, PERTH); 12.3 km SW along Parmango Rd from junction of Balladonia Rd, 23 July 2002, *R. Davies 10402* (AD, PERTH); c. 1 km E of Babkin, 18 Aug. 1979, *L. Haegi 1829* (K, L, MEL, NSW, PERTH); Lake Hurlstone Nature Res., W of main rd, Hyden Lake King Rd, 26 Sep. 2001, *J. Kellermann 360* (AD); 12.5 km by rd (c. E) from Pingrup on Pingrup-Ravensthorpe Rd, 11 Oct. 1975, *G. Perry 369* (AD, PERTH); Manmanning town site, 9 Aug. 1986, *B.H. Smith 684* (AD, CANB, HO, MEL); Avon Loc. 19405, 1 mile SW of Manmanning, 29 July 1989, *B.H. Smith 1180* (AD, BRI, CBG, MEL); Unallocated Crown Land [Yilgarn Ranges Survey], 1 km E of Forrestania Southern Cross Rd, c. 6 km S of Mt Holland, 26 Sep. 2009, *W.A. Thompson & J. Allen 1367* (PERTH).

## *Spyridium cordatum* (Turcz.) Benth.

*Fl. Austral.* 1: 430 (1863). — *Cryptandra cordata* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 459 (1858). — **Type citation:** "Nova Hollandia, Drum. V. n. 230." **Holotype:** Nova Hollandia, *J. Drummond 5: 230* [*"Drum: coll: V n 230"*] (KW001001107). **Isotypes:** S. Australia, *Drummond 230* (K001096729); *J. Drummond 230* (MEL2103313); Swan River to Cape Riche, *Drummond (colln 5th) 230* (K001096728); 1849, *Drummond 5th collection 230* (P06766742, ex BM); *J. Drummond 5th coll. 230* (PERTH01179829, ex BM).

Evergreen *shrubs*, 0.05–0.45 m high, without spines, young stems covered with dense intertwined matted stellate hairs, first rusty then grey. *Leaves* alternate: *stipules* 1.1–2.1 mm long, narrowly triangular or triangular, free, pubescent; *petiole* 0.5–2.2 mm long; *lamina* broadly ovate or cordate, 1.6–4.5 mm long, 1.7–4.3 mm wide, base cordate or broadly obtuse, margins recurved, apex obtuse or emarginate, glabrous and tuberculate above, rarely smooth, or with sparse stellate hairs, below densely grey stellate-pubescent, with hairs rusty on midrib and along edge. *Inflorescences* comprising terminal or axillary heads, 3–4 mm long, 3–7 mm wide, with c. 13–30 flowers, without white felty floral leaves; *bracts* ovate, 1–2.2 mm long. *Flowers* 5-merous, bisexual, white or cream, sometimes pale pinkish, sessile. *Hypanthium* cup-shaped, tube 0–0.4 mm long, 0.7–1 mm diameter, ± densely woolly-pubescent with long stellate hairs. *Sepals* 0.8–1 mm long, spreading, medium to densely stellate-pubescent, grey or sometimes rusty. *Petals* cucullate, 0.4–0.6 mm long, distinctly but shortly clawed. *Stamens* 0.4–0.5 mm long, incurved to erect. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior; roof stellate-pubescent; *style* 0.4–1 mm long, glabrous with some hairs in bottom half. *Fruit* obovoid, 1.7–2 mm long, purple to dark reddish-brown; torus in upper third. *Seeds* 1.1–1.2 mm long, orange to brown with dark speckles; *aril* pale yellowish. **Fig. 2.**

***Illustrations:*** B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 584 (1998).

***Distribution & habitat.*** The species is endemic to W.A. and extends from west of Lake King east to Mt Ragged and south-west towards Gairdner, but most records are from the western part of the range, with disjunct occurrences in the vicinity of Mt Ragged in Cape Arid National Park (N.P.). It is mainly recorded in gravelly or stony to rocky sites with clay/loam or sandy soils, usually in shrublands or woodlands dominated by eucalypt species with a mallee habit (Rye 1996).

***Phenology.*** Flowers Aug.–May; fruits Sep.–Oct.

***Notes.*** Following a molecular analysis of the genus (Clowes *et al.* 2022), Kellermann & Clowes (2022) published *Spyridium longicor* Kellermann & C.Clowes for a taxon that was previously regarded as comprising intermediates between *S. cordatum* and *S. microcephalum*. *Spyridium cordatum* differs from *S. longicor* in having shorter and broader leaves (usually as wide as long) with cordate bases, and smaller flower-heads with shorter flowers.

***Typification.*** The holotype specimen in KW consists of two flowering twigs, showing the typical broad heart-shaped leaves. All plant fragments of the type specimen are at a similar stage of development, with older partly enlarging flower-heads.

***Etymology.*** From the Latin *cordatus* (heart shaped), in reference to the shape of the leaves.

### *Selected specimens examined*

WESTERN AUSTRALIA. 16 km N of Moolyall Rocks on Hayes Rd, 25 Mar. 1983, *M.A. Burgman 1028 & S. McNee* (PERTH); 1.1 km along Elverdton Rd from the junction with Hopetoun Rd, 8 Sep. 2017, *G. Byrne 6544* (AD, PERTH); Carney Rd, N of Cowalellup Rd, W rd res., old gravel/stockpile site, 13 Oct. 2017, *C. Clowes CC 528 & M.W. Pratt* (AD, MELU, PERTH); Bedford Harbour Rd, 400 m N of Jerdacuttup Rd, 17 Oct. 2017, *C. Clowes CC 530 & M.W. Pratt* (AD, MELU, PERTH); Dunn Rock Nature Res., c. 33 km SSW of Lake King townsite, 17 Oct. 1999, *G.J. Keighery & N. Gibson 4182* (AD, PERTH); Disused gravel pit, off Hayes Rd, E of Lake King-Ravensthorpe Rd, 27 Sep. 2000, *J. Kellermann 370* (AD, B, BAA, CANB, K, MEL, NY, PERTH); c. 8 km N of Ravensthorpe, c. 30 m along Archer Drive, N of Floater Rd, 11 Sep. 2000, *B.J. Mole 446 & C. Mole* (AD, B, MEL, NY); 37 km SE of Ongerup, 14 Apr. 1975, *K. Newbey 4964* (AD, PERTH); c. 20 km by rd SSE of Ravensthorpe on Hopetoun Rd, 17 Sep. 1976, *L. Haegi 1005* (AD, MEL, PERTH); At foot of W side of Mt Ragged, 1 Nov. 1968, *J.W. Wrigley WA/68 5278* (CANB, PERTH).

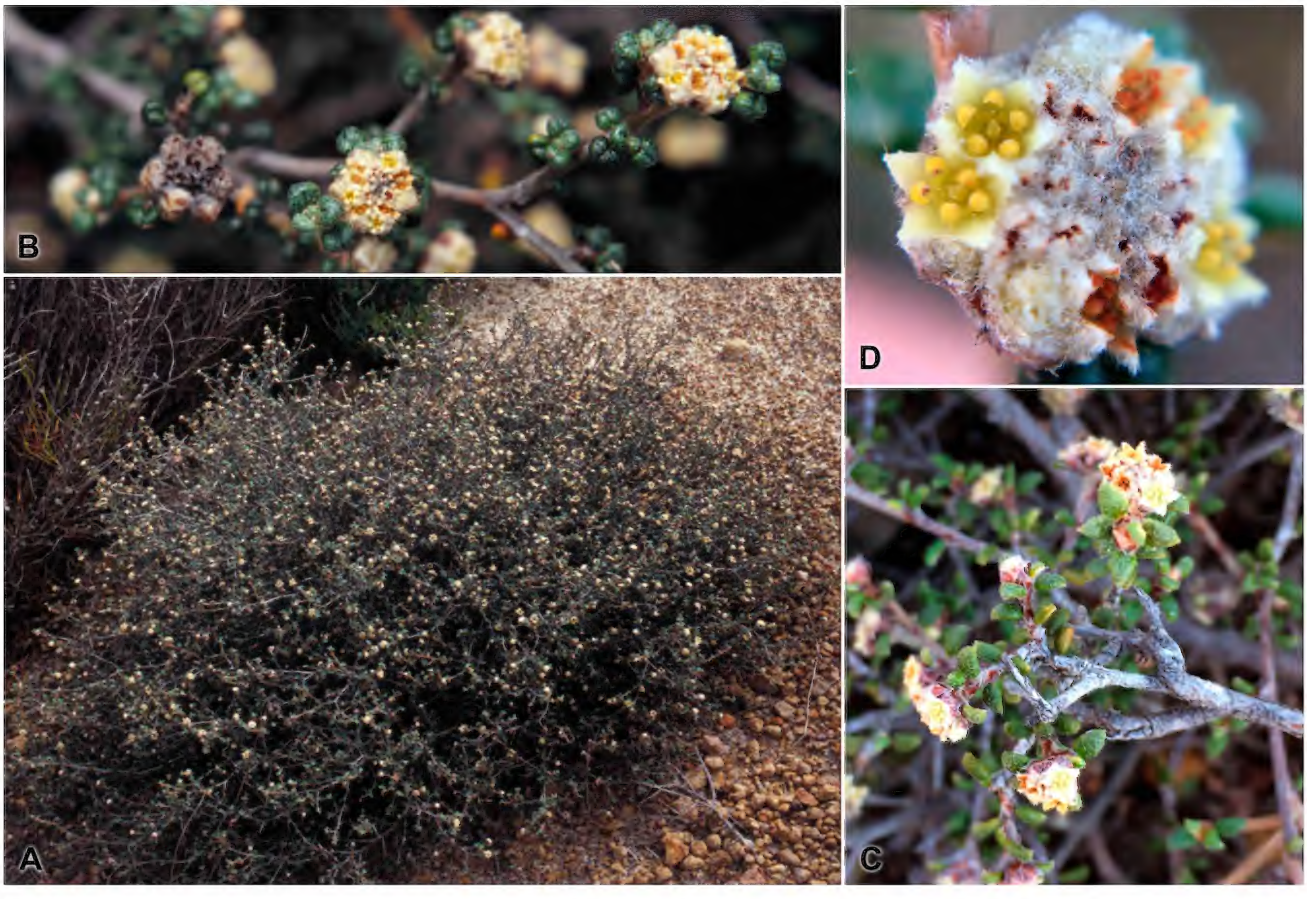


**Fig. 2.** *Spyridium cordatum*, variants with totally glabrous and smooth leaves, N of Ravensthorpe (A, B), and with tuberculate leaves with a few stellate hairs, near Gairdner (C) and E of Ravensthorpe (D), W.A.: **A** habit; **B**, **C** flowering branches; **D** close-up of flowerhead. — A, B *J. Kellermann 370*; C *C. Clowes 528 & M.W. Pratt*; D *CC 530 & MWP*. Photos by J. Kellermann (A, B) & C. Clowes (C, D).

***Spyridium microcephalum*** (Turcz.) Benth.

*Fl. Austral.* 1: 434 (1863). — *Cryptandra microcephala* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 458 (1858). — **Type citation:** "Nova Hollandia, Drum. V. n. 234". **Holotype:** Nova Hollandia, *J. Drummond 5: 234* ["*Drum. coll: V n 234*"] (KW001001108). **Isotypes:** W.A., 1849, *J. Drummond, 5th collection, 234* (PERTH01173634, ex BM); Swan River, *Drummond 234* (K001096734); W. Australia, *Drummond 234* (P06766733, ex BM). **Excluded specimens:** W.A., *J. Dr.*[*ummond*] *234* (MEL2290282); W.A., *J. Dr.* [*ummond*] (MEL98612).

*Spyridium denticuliferum* Diels in Diels & Pritzel, *Bot. Jahrb. Syst.* 35(2–3): 355 (1904). — **Type citation:** "in distr. Eyre pr. Hammersley River in fruticetis apertis arenosis flor. m., Oct. (D. 4929)". **Holotype or syntypes:** B (destroyed). **Lectotype (designated here):** Hamersley River, 12 Oct. 1901, *L. Diels 4929* (PERTH01179810, ex B).

Evergreen *shrubs*, 0.1–1.5 m high, without spines, young stems covered with dense stellate hairs, first rusty then grey, soon ± glabrous. *Leaves* alternate or fasciculate: *stipules* 1.7–2.6 (–4) mm long, narrowly triangular or triangular, free, sparsely pubescent; *petiole* 0.7–1.6 mm long; *lamina* narrowly ovate to narrowly elliptic or ovate to elliptic or linear, 4–7.5 (–10) mm long, 0.9–2 (–2.6) mm wide, base cuneate or obtuse, margins recurved or revolute, apex acute or obtuse or apiculate, sometimes with a small mucro, smooth or sometimes tuberculate above, usually glabrous, rarely with sparse stellate hairs, below densely grey stellate-pubescent. *Inflorescences* comprising terminal or axillary heads, 3–5 mm long, 3.5–9 mm wide, with usually 10–20 flowers, without subtending felty floral leaves; *bracts* ovate, 1.3–2.3 mm long. *Flowers* 5-merous, bisexual, white, cream or yellow; *pedicel* 0–3.5 mm long. *Hypanthium* cup-shaped, tube 0.4 (–0.6) mm long, 0.8–1.3 mm diameter, densely stellate-hairy, base also with dense flexuose simple hairs. *Sepals* 0.8–1 mm long, erect or slightly spreading, woolly-pubescent with dense stellate hairs, greyish or rusty. *Petals* cucullate, 0.4–0.7 mm long, distinctly clawed. *Stamens* 0.4–0.6 mm, erect. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior; roof stellate-pubescent; *style* 0.8–1.1 mm long, glabrous, with stellate hairs at base. *Fruit* obovoid, 2–2.2 mm long, purple to dark reddish-brown; torus in upper third. *Seeds* 1.3–1.4 mm long, orange to reddish-brown, uniformly coloured; *aril* pale yellowish. **Fig. 3.**

***Illustrations:*** B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 585 (1998).

***Distribution & habitat.*** *Spyridium microcephalum* is endemic to W.A., extending from Dongolocking

**Fig. 3.** *Spyridium microcephalum* near Lake Grace (A, B) and W of Gairdner (C–E), W.A.: **A** habit; **B** flowering branch; **C** fascicle of leaves; **D**, **E** close-up of flower-heads. — A, B *J. Kellermann 333*; C–E *C. Clowes 527 & M.W. Pratt*. Photos by J. Kellermann (A, B) & C. Clowes (C–E).

Res. east to the Great Australian Bight and south-east to Fitzgerald River N.P. It occurs in sand or clay, sometimes on hills or with limestone, in the west often in gravelly or granitic soils, in the east often on limestone, commonly in heathland or shrubland vegetation dominated by mallee.

***Phenology.*** Flowers Mar.–Nov.; fruits Mar.–Nov.

***Typification of* Cryptandra microcephala.** The two Drummond specimens at MEL (MEL2290282 and MEL98612) seem to have been collected from a different location from the types, as they have much shorter and thinner leaves compared to the holotype and the other isotypes, listed above. As such, they are excluded from the type series.

***Typification of* Spyridium denticuliferum.** Diels & Pritzel (1904–1905) stated in the introduction of *Fragmenta phytographiae Australiae occidentalis* that Diels' own collections were all deposited in the Berlin herbarium, in contrast to the specimens by his fellow traveller Pritzel, who collected several sets which are distributed in many different herbaria. However, it is not clear from the protologue how many duplicates (if any) of the type gathering of *S. denticuliferum* were deposited in Berlin. If there was just one specimen, it was the holotype; if several, those were syntypes. In any case, the holotype (or syntypes) of *S. denticuliferum* at B was (were) destroyed during World War II (R. Vogt, pers. comm, Feb. 2006; for general information, see also: Pilger 1953; Hiepko 1987).

However, C.A. Gardner, Government Botanist in W.A., visited Berlin in 1937 and received fragments of many of Diels' types, which he removed with Diels' permission. Diels and Gardner subsequently continued to exchange specimen. Since the originals were later destroyed, these fragments and duplicates at PERTH are the only remaining original material of many of Diels' names (Underwood 2011). A fragment of the original collection of *S. denticuliferum* at PERTH is here designated as the lectotype.

***Etymology.*** From the Greek μικρο- (*micro-*; little, small) and κεφαλη (*cephale*; head), on account of the small flower-heads of the species.

### *Selected specimens examined*

WESTERN AUSTRALIA. E fence line of Kent Location 1910 nr Roberts Rd, 9 Nov. 2004, *S. Barrett 1302* (PERTH); On the Nyabin-Kukerin Rd, 1 Sep. 2016, *G. Byrne 5922* (AD, PERTH); Carney Rd, N of Cowalellup Rd, W rd res., old gravel/stockpile site, 13 Oct. 2017, *C. Clowes CC 527 & M.W. Pratt* (AD, MEL, MELU); 9 miles E of Rabbit Proof Fence gate (E of W Mt Barren) on tk to Fitzgerald River, 9 Mar. 1970, *A.S. George 9483* (AD, PERTH); Unvested res. 31425, Twertatup, 28 Apr. 1983, *S.J. Hancock 04019* (PERTH);

10 km N Eyre, 4 Apr. 1984, *G.J. Keighery 7215* (CANB, K, PERTH); Big res. on N side of Dumbleyung-Lake Grace Rd, 7.22 km W of Tarin Rock Rd South intersection, 25 Sep. 2001, *J. Kellermann 333* (AD, B, E, K, NY); Unnamed Nature Res., 2.4 km N of Dualling Rd on Kukerin Rd, c. 4 km N of Nyabing, 21 Sep. 1996, *B.J. Lepschi & T.R. Lally BJL 3033* (AD, BRI, CANB, MEL, PERTH); c. 27.36 km W of Lake Grace township on rd to Kukerin, 12 Sep. 2000, *B.J. Mole 465 & C. Mole* (AD, B, BAA, MEL); 20 km W Mt Ragged, 16 Nov. 1976, [*E.*] *Wittwer W.1895* (PERTH).

### ***Spyridium oligocephalum*** (Turcz.) Benth.

*Fl. Austral.* 1: 433 (1863). — *Trymalium oligocephalum* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 460 (1858). — **Type citation:** "Nova Hollandia Drum. V. n. 236". **Holotype:** Nova Hollandia, *J. Drummond 5: 236* [*"Drum: coll; V n 236"*] (KW001001112). **Isotypes:** Swan River to Cape Riche, *Drummond 236 (5th coll$^{n}$)* (K000732093, ex Herb. Benth.); Swan River, *Drummond 236* (K000732094, ex Herb Hook.); Western Australia, Cape Riche, 1849, *J. Drummond 5th Collection 236* (PERTH01179802, ex BM); W.A., *J. Dr.*[*ummond*] *236* (MEL2104245)

*Spyridium kalganense* Diels in Diels & Pritzel, *Bot. Jahrb. Syst.* 35(2–3): 355 (1904). — **Type citation:** "in distr. Stirling in planitiebus rivi Kalgan superioris in arenosis fruticulosis flor. M. Oct. (D. 4607)". — **Holotype or syntypes:** B (destroyed). **Lectotype (here designated):** Humus soil, Kalgan River, 4 Oct. 1901, *L. Diels 4607* (PERTH01174045, ex B).

Evergreen *shrubs*, 0.6–1.2 m high, without spines, young stems with dense stellate hairs, grey or rusty (especially on young shoots). *Leaves* alternate: *stipules* (2.2–) 2.5–4 (–5) mm long, broadly ovate or ovate, connate behind the petiole for most of their length, with a few stellate hairs along the midrib; *petiole* 1.4–2.3 mm long; *lamina* narrowly ovate or (very) narrowly elliptic, 6–13 mm long, 1–2 mm wide, base cuneate, margins revolute, apex obtuse straight, smooth and glabrous above, below with dense grey or rarely rusty stellate hairs. *Inflorescences* comprising terminal heads, 3–5 mm long, 5–8 mm wide, with up to 20 flowers, with floral leaves covered in a dense white felty indumentum of stellate hairs; *bracts* ovate, 1.5–2.5 mm long, sparsely pubescent in middle. *Flowers* 5-merous, bisexual, white or cream, covered with dense stellate hairs; *pedicels* 0–1.5 mm long. *Hypanthium* cup-shaped, tube 0.2–0.4 mm long, 1.2–1.4 mm diameter, some hairs at base also rusty. *Sepals* 0.9–1.1 mm long, erect. *Petals* cucullate, 0.5–0.7 mm long, distinctly but shortly clawed. *Stamens* 0.4–0.6 mm long, incurved. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior to semi-inferior; roof pubescent with stellate hairs; *style* 0.5–0.6 mm long, glabrous. *Fruit* obovoid, c. 2 mm long, grey to reddish-brown; torus in upper third. *Seeds* c. 1.1 mm long, brown or yellowish with dark speckles; *aril* pale yellowish. **Fig. 4A–C.**

***Illustrations:*** B.L. Rye, *Nuytsia* 10: 129, Fig. 2I–N (1995); B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 586 (1998).

***Distribution & habitat.*** The taxon is endemic to W.A. and ranges from near the Kalgan River east to Fitzgerald River N.P. It occurs in sandy soils or sandy clay and is recorded either in heathlands or in shrublands dominated by eucalypt species with a mallee habit.

***Phenology.*** Flowers and fruits: Mar., July–Oct.

***Note.*** *Spyridium oligocephalum* can be distinguished from the closely related *S. subochreatum* by its orange-brown bracts and stipules and long hairs on the sepals (vs dark red-brown stipules and bracts and short hairs on sepals). It occurs on non-calcareous rock, while *S. subochreatum* prefers limestone and sandy soils.

Rye (1996) placed the species into the *Spyridium oligocephalum* group, which also includes *S. polycephalum* and *S. subochreatum*. The group is characterised by large, papery stipules, which are fused for more than half of their length, an undulate annular disk, and flowers that are arranged in head-like condensed cymes.

***Conservation status.*** Listed as a Priority 3 taxon in W.A. (TSSC 2022).

***Typification of* Spyridium kalganense.** As with *S. denticuliferum*, above, the holotype (or syntypes) at B was (were) destroyed, but a fragment of the original specimen is available in PERTH and here designated as the lectotype.

***Etymology.*** From the Greek ολιγος (*oligos*; few) and κεφαλη (*cephale*; head), because of the apparently low numbers of flower-heads in the taxon.

#### ***Selected specimens examined***

WESTERN AUSTRALIA [precise locality withheld for conservation reasons]. E of Fitzgerald River Inlet, Sep. 1970, *T.E.H. Aplin 3678* (CANB, PERTH); Hopetoun, 18 Oct. 2017, *C. Clowes CC 536* (AD, MEL, MELU); Dempster Inlet, 16 July 1970, *A.S. George 10069* (PERTH); S of Whoogarup Range, 17 Mar. 1972, *A.S. George 11291* (PERTH); S of Pingrup, 9 Jan. 1975, *K. Newbey 4948* (PERTH); Fitzgerald Inlet, Fitzgerald River N.P., 22 July 1971, *A.S. Weston 6396* (CANB, PERTH).

### ***Spyridium polycephalum*** (Turcz.) Rye

*Nuytsia* 10: 128 (1995). — *Trymalium polycephalum* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 460 (1858). — **Type citation:** "Drum. Coll. V. n. 91 et forte n. 235 (specimen floribus non evolutis)". **Lectotype:** Nova Hollandia, *J Drummond 5: 91* [*"Drum: coll: V n 91"*] (KW001001113), *fide* N.G.Marchant in P.S.Short, *Hist. Syst. Bot. Australas.* 124 (1990), as "holotype". **Isolectotypes:** S.W. Australia, 1856, *J. Drummond no. 91 Suppl. to 5th Coll.* (K000732097, ex Herb. Hook.); W.A., *J. Dr.*[*ummond*] *91* (MEL 227045); S.W. Australia, *Drummond 91 (Suppl: to 5th coll:)* (GH00048669, ex K). **Residual syntypes:** Nova Hollandia, *J. Drummond 5: 235* [*"Drum: coll: V n 235"*] (KW); S.W. Australia, *Drummond*

**Fig. 4. A–C** *Spyridium oligocephalum* near Hopetoun, W.A.: **A** habit; **B** flower-heads subtended by white pubescent floral leaves; **C** young shoots. **D**, **E** *S. polycephalum*, E of Jerramungup (D) and N of Ravensthorpe (E), W.A.: **D** habit; **E** infructescences and young shoots. — A–C *C. Clowes CC 536*; D *C. Clowes 525 & M.W. Pratt*; E *CC 535 & MWP*. Photos by C. Clowes.

*235* (K000732095, ex Herb. Hook., mounted with K000732096); Swan River to Cape Riche, *Drummond 235 (5th coll^n)* (K000732096, ex Herb. Benth., mounted with K000732095); W.A., 1849, *J. Drummond, V 235* (PERTH1636170).

Evergreen *shrubs*, 0.3–1 m high, without spines, young stems with grey or rusty stellate hairs. *Leaves* alternate: *stipules* (2.3–) 3–5 (–7) mm long, narrowly to broadly ovate, connate behind the petiole for c. 80% of their length, sparsely to moderately pubescent especially along midrib; *petiole* 0.5–1.5 (–3) mm long; *lamina* narrowly ovate or (very) narrowly elliptic, 4–14 (–16) mm long, 0.9–2 (–3.2) mm wide, base narrowly cuneate or cuneate, margins revolute or sometimes recurved, apex obtuse, pubescent with sparse to dense stellate hairs above and at least some leaves tuberculate or papillose below with dense grey or sometimes rusty stellate hairs. *Inflorescences* comprising terminal heads, 4–8 mm long, 6–12 mm wide, with usually 20–30 flowers, each head usually subtended by 2–5 whitish felty-hairy floral leaves; *bracts* ovate, 1.5–3 mm long, moderately pubescent, especially in the middle. *Flowers* 5-merous, bisexual, white or cream, densely woolly-pubescent with flexuose grey and rusty simple and stellate hairs. *Hypanthium* cup-shaped and shortly tubular, 0.2–0.4 mm long, 1–1.3 mm diameter. *Sepals* 0.8–1.1 mm long, erect. *Petals* cucullate, 0.5–0.7 mm long, distinctly clawed. *Stamens* 0.3–0.7 mm long, incurved. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior; roof pubescent with dense stellate hairs; *style* 0.5–0.8 mm long, glabrous. *Fruit* obovoid, 2–2.5 mm long, densely covered in hairs, grey; torus in upper third to apical. *Seeds* 1.1–1.8 mm long, orange to brown or reddish-brown, uniformly coloured or rarely spotted; *aril* pale yellowish. **Fig. 4D, E.**

***Illustrations:*** B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 586 (1998).

***Distribution & habitat.*** Endemic to W.A., from near Harrismith east to Mt Arid in Cape Arid N.P. It occurs mainly in sandy soils, often on rocky hills, and is recorded from heathlands or shrublands, the latter commonly dominated by mallee.

***Phenology.*** Flowers and fruits: Apr.–Nov.

***Note.*** The species is related to *Spyridium subochreatum* and *S. oligocephalum*, sharing with them the large stipules, which are fused for more than half of their length. *Spyridium polycephalum* can be distinguished by the very hairy flowers, in particular the long hairs on the sepals, and seeds that are usually uniformly coloured.

***Typification of* Trymalium polycephalum.** The lectotype of the name *Trymalium polycephalum* Turcz. was

inadvertently designated by Marchant (1990; see Art. 9.10, Turland *et al.* 2018). The second specimen (syntype) cited by Turczaninow in the protologue as "n. 235 (specimen floribus non evolutis)" has been found recently among the unmounted specimens in KW-TURCZ, following an email request by J. Kellermann to S. Mosyakin. It was not initially recognised as part of the original material, because it is not annotated by Turczaninow.

***Etymology.*** From the Greek πολυ- (*poly-*; many) and κεφαλη (*cephale*; head), because of the numerous flower-heads in the holotype specimen.

### *Selected specimens examined*

WESTERN AUSTRALIA. Regenerating disused gravel pit off Hayes Rd, 500 m from Lake King Rd, 10 Jan. 1999, *M. Bennett 427* (PERTH); Old Newdegate Rd, W of Millsteed Rd, 26 Feb. 2011, *G. Byrne 4081* (AD, PERTH); Park Rd, S rd res., 6.3 km from Diagonal Rd, 13 Oct. 2017, *C. Clowes CC 525 & M.W. Pratt* (AD, MEL, MELU); Hayes Rd, 500 m E from Newdegate-Ravensthorpe Rd, c. 300 m N of Hayes Rd, past the old gravel pit, 17 Oct. 2017, *C. Clowes CC 535 & M.W. Pratt* (AD, MEL, MELU); W side of Mt Arid, Cape Arid N.P., 30 June 1976, *A.S. George 14304* (PERTH); SE side and base of Mt Arid, Cape Arid N.P., 23 Nov. 1985, *M. Hardie 09* (NSW, PERTH); c. 18 km NNW of Young River crossing on Ravensthorpe-Esperance main rd, 16 Dec. 1968, *E.N.S. Jackson 1447* (AD); Near W border of Shire of Esperance, Location 1110, c. 40 km ENE of the coast at Stokes Inlet, 16 Oct. 1968, *A.E. Orchard 1581* (AD, CANB, K, NBG, PERTH); 48 km by rd (c. E) from Pingrup on Pingrup-Ravensthorpe Rd, 11 Oct. 1975, *G. Perry 401* (AD, PERTH); Site 1, Park Rd, 600 m W of Jerramungup Shire boundary, NE of Ongerup, 21 June 2004, *L. Strahan 228* (CANB, PERTH).

### ***Spyridium spadiceum*** (Fenzl) Benth.

*Fl. Austral.* 1: 428 (1863). — *Trymalium spadiceum* Fenzl in Endl. *et al.*, *Enum. Pl.* 26 (1837). — *Cryptandra spadicea* (Fenzl) F.Muell., *Syst. Cens. Austral. Pl.* 61 (1882). — **Type citation:** "King Georges Sound. (Hügel.)". **Holotype:** King Georges Sound, Hügel (W0046837).

*Trymalium thomasioides* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 459 (1858). — **Type citation:** "Nova Hollandia, Drum. V. n. 231". **Holotype:** Nova Hollandia, *J. Drummond 5: 231* ["*Drum: coll: V n 231*"] (KW001001114). **Isotypes:** Western Australia, 1849, *J. Drummond 5th collection no. 231* (PERTH01534971, ex BM); S. Australia, *Drummond 231 (5th Coll.)* (K000732105); Western Australia, *J. Drummond 231* (MEL2104156); W. Australia, *Drummond 231* (P06766706, ex BM).

*Pomaderris hirsuta* Steud. in Lehm., *Pl. Preiss.* 1(2): 184 (1845). — **Type citation:** "In rupestribus ad tergum montis Clarence, 30 Sept. 1840. Herb. Preiss. No. 1673a". **Lectotype (here designated):** In rupestribus ad tergum montis Clarence, N. Holl. Occ. Austr., *L. Preiss 1673a* (P06766704, ex Herb. Steudel). **Isolectotypes:** In rupestribus ad tergum montis Clarence, Sem. Num. 402, Septembr. 3 40, *L. P.*[*reiss*] *1673* (LD1099226); In rupestribus montis Clarence, 30 Sept. 40, *L. Preiss 1673a* (MEL2290880).

Evergreen *shrubs*, 0.5–3 m high, without spines, young stems densely pubescent with greyish stellate and rusty long flexuose simple hairs. *Leaves* alternate: *stipules* 3.5–6 mm long, narrowly ovate or ovate, free, sparsely pubescent at base and middle; *petiole* 2–5 mm long; *lamina* narrowly ovate or ovate, 9–30 (–45) mm long, (5–) 7–12 (–15) mm wide, base obtuse, margins recurved, apex obtuse, medium to densely pubescent with small stellate hairs (occasionally also short simple hairs) and scattered long simple hairs above, below pubescent with dense white to grey stellate hairs and longer rusty simple hairs. *Inflorescences* comprising terminal head-like clusters, 5–25 mm long, 10–30 mm wide, with c. 15–17 or more flowers, subtended by several floral leaves, usually slightly smaller than the vegetative leaves and covered in a dense white felty indumentum of stellate hairs. *Flowers* 5-merous, bisexual, white or cream, covered in medium to dense greyish stellate and simple hairs; *pedicels* 0–1.5 mm long. *Hypanthium* cup-shaped with no apparent tube, 1–1.4 mm diameter, hairs denser at base. *Sepals* 1–1.1 mm long, spreading. *Petals* cucullate, 0.6–0.8 mm long, distinctly clawed. *Stamens* 0.5–0.6 mm long, incurved to erect. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior to semi-inferior; roof pubescent with stellate hairs; *style* c. 0.4 mm long, glabrous. *Fruit* obovoid, 1.5–2 mm long, grey to black; torus in upper third. *Seeds* 1–1.3 mm long, brown to reddish brown, with some faint darker spots; *aril* pale yellowish. **Fig. 5.**

***Illustrations:*** B.L. Rye, *Nuytsia* 10: 131, Fig. 3A–D (1995); B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 583 (1998).

***Distribution & habitat.*** The species occurs on granitic hills in Porongurup Range and at Albany, one record describing the vegetation as a thicket and another as *Eucalyptus megacarpa* woodland.

***Phenology.*** Flowers and fruits: Oct.–Feb.

***Conservation status.*** The species is listed as Priority 4 in W.A. (TSSC 2022).

***Typification of* Trymalium spadiceum.** Only one specimen of *S. spadiceum* collected by Hügel is known from W, where Fenzl worked; as such this is accepted as the holotype of the name. The mention of F.L. Bauer as collector in the JACQ database is in error.

***Typification of* Pomaderris hirsuta.** It is quite possible that Steudel saw several collections of *Preiss 1673a*, but only retained one in his private herbarium (now in P). The Preiss collections in LD are generally regarded as the "top set", but the specimen in Steudel's own herbarium is preferable as the lectotype. The LD & P specimens have annotations in the same handwriting, presumably Steudel's, i.e. he has seen both collections.

**Fig. 5.** *Spyridium spadiceum* near Albany, W.A.: **A** flowering branch, with inflorescences subtended by white pubescent floral leaves; **B–D** inflorescences. — A–C *C. Clowes CC 520 & M.W. Pratt*; D *CC 524 & MWP*. Photos by C. Clowes.

Other sheets labelled *Preiss 1673b* (LD1068029, HBG510058, S-G-10550, P06766707, P06766708 ex Herb. Steudel) or only *Preiss 1673* in some herbaria (BR0000013470081, M0211890, K000732103, K000732103, P06766703) are types of a different taxon: *Pomaderris commixta* Steud. [current name: *Spyridium majoranifolium* (Fenzl) Rye].

***Etymology.*** From the Latin *spadiceus* (date-coloured, bright brown; see Stearn 1983), possibly on account of the dark reddish-brown inflorescence bracts of the species (as displayed by the holotype), or because of the conspicuous rusty indumentum on young branches.

### *Selected specimens examined*

WESTERN AUSTRALIA [precise localities withheld for conservation reasons]. W of the Great Australian Bight, 29 Jan. 1919, *Anon.* (AD, ex Herb. J.M. Black); Gull Rock N.P., 9 Oct. 2017, *C. Clowes CC 520 & M.W. Pratt* (AD, MELU, PERTH); Mt Clarence, 12 Oct. 2017, *C. Clowes CC 524 & M.W. Pratt* (AD, MELU, PERTH); Mt Clarence, King George Sound, 6 Nov. 1927, *C.A. Gardner s.n.* (PERTH); Porongurups, 11 Dec. 1964, *A.S. George s.n.* (PERTH); Porongurup Range, 30 km NNW of Albany, 17 Nov. 1986, *G.J. Keighery 11729* (AD, PERTH); Porongurup Range, 4 Feb. 1992, *G.J. Keighery 12707* (PERTH); Gull Rock N.P., 7 Sep. 2001, *E.M. Sandiford EMS 602* (PERTH); NE of Albany, 5 Sep. 2008, *E.M. Sandiford & D.A. Rathbone 1653* (PERTH).

### ***Spyridium subochreatum*** (F.Muell.) Reissek

*Linnaea* 29: 287 (1858). — *Trymalium subochreatum* F.Muell., *Defin. Austral. Pl.* 42 (1855). — *Cryptandra subochreata* (F.Muell.) F.Muell., *Syst. Cens. Austral. Pl.* 61 (1882). — *Spyridium subochreatum* (F.Muell.) Benth. var. *subochreatum*: J.M.Black, *Trans. Proc. Roy. Soc. S. Austral.* 49: 273 (1925). — **Type citation:** "In the desert-scrub on the Murray River." **Lectotype (here designated):** In the Murray desert, *F. Mueller s.n.* (MEL 710602). **Residual syntypes:** Murray Desert, *F. Mueller s.n.* (BR0000013470104); Murray Scrub, *F. Mueller s.n.* (MEL710601A); Ad fl. Murray, Murray River, Oct. 1848, *F. Mueller s.n.* (MEL710603A). **Possible syntypes:** Murray River [, *F. Mueller s.n.*] (L0552319 = L.2327579); Australia felix [, *s.coll.*] (U.1541278, top middle and bottom left & middle branch).

*Trymalium behrii* F.Muell. ex Reissek, *Linnaea* 29: 274 (1858). — **Type citation:** "Murray-Scrub (Dr. F. Mueller)". **Lectotype (here designated):** Murray Scrub, *Dr. Behr* (MEL710601B). **Residual syntype:** Ad fl. Murray, Murray River, Oct. 1848, *F. Mueller s.n.* (MEL710603B).

*Pomaderris subochreata* F.Muell. ex Reissek, *Linnaea* 29: 287 (1858), *nom. inval. pro syn.*

*Cryptandra pauciflora* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 458 (1858). — *Spyridium pauciflorum* (Turcz.) Benth., *Fl. Austral.* 1: 432 (1863). — **Type citation:** "Nova Hollandia, Drum. V. n. 233". **Holotype:** Nova Hollandia, *J. Drummond 5: 233*

**Fig. 6.** *Spyridium subochreatum* on Eyre Peninsula, S.A. (A, F), the South Australian mallee (B, C, E) and near the Little Desert, Victoria (D): **A** habit; **B–C** young branches, variants with sparsely hairy leaves (B) and densely stellate-pubescent leaves (C); **D** flowering branches; **E–F** inflorescences. — A *J. Kellermann 760 & F.J. Nge*; B *JK 841 & FJN*; C *JK 785 & FJN*; D *JK 939 & FJN*; E *JK 634*; F *JK 761 & FJN*. Photos by J. Kellermann.

[*"Drum: coll: V n 233"*] (KW001001110). **Isotypes:** Swan River to Cape Riche, *Drummond 233 (5th coll[n])* (K000732098, ex Herb. Benth.); W. Australia, *Drummond 233* (P06766714, ex BM); *Drummond V 233* (BM, *n.v.*, *fide* J.G. West, pers. comm.).

*Spyridium subochreatum* var. *laxiusculum* J.M.Black, *Trans. Proc. Roy. Soc. S. Austral.* 49: 273 (1925). — **Type citation:** "Keith; Wirrega". **Lectotype (here designated):** Keith (cemetery), 23 Nov. 1917, [*J.M. Black s.n.*] (AD98132267, two large branches, with a cover sheet with annotations and drawings; Fig. 7D). **Residual syntypes:** Keith, 23 Nov. 1917, [*J.M. Black s.n.*] (AD98132267, two separate branches and a fragment of an inflorescence; Fig. 7A–C); Keith (90 mile desert), 23 Nov. 1917, *J.M. Black s.n.* (K000618744, "Flora of S. Australia No. 6"; MEL710600); Wirrega, 1 Oct. 1916, [*T.G.B. Osborne s.n.*] (AD97611498); Wirrega, *T.G.B. Osborne s.n.* (AD98132267, several flowers and small part of inflorescence; Fig. 7E).

Evergreen *shrubs*, 0.2–1.5 m high, without spines, young stems covered in stellate hairs, mostly grey, sometimes rusty. *Leaves* alternate: *stipules* 1.4–5 mm long, narrowly triangular or triangular or narrowly ovate or ovate, connate behind the petiole for more than half of their length, glabrous or moderately hairy in middle; *petiole* 0.7–2 mm long; *lamina* narrowly ovate to narrowly obovate or ovate or elliptic, (3–) 4–15 (–19) mm long, 0.9–4 (–6.2) mm wide, base narrowly cuneate or cuneate or obtuse, margins revolute or sometimes recurved, apex acute or obtuse, smooth and glabrous or sometimes tuberculate above, or glabrescent or covered with stellate hairs, below covered with a dense stellate indumentum. *Inflorescences* comprising terminal or axillary dense to lose cymose panicles, 4–18 mm long, 6–14 mm wide, with c. 10–50 flowers, without white felty floral leaves; *bracts* ovate to orbicular, 1–3.5 mm long. *Flowers* 5-merous, bisexual, white or cream, medium to densely stellate-pubescent; pedicels 0–3 mm long. *Hypanthium* cup-shaped with no apparent tube, 1–1.7 mm diameter. *Sepals* 1.1–1.8 mm long, spreading, more densely hairy towards tips. *Petals* cucullate, 0.6–1 mm long, ± distinctly clawed. *Stamens* 0.6–0.9 mm long, incurved. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior; roof pubescent with dense stellate hairs; *style* 0.4–0.7 mm long, glabrous. *Fruit* obovoid, 2.2–3.2 mm long, grey; torus in the upper third. *Seeds* 1.2–2.1 mm long, reddish brown, faintly spotted; *aril* pale yellowish. **Fig. 6.**

***Illustrations:*** J.P. Jessop & H.R. Toelken, *Fl. S. Austral.* 2: 818, Fig. 430D (1986); B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 583 (1998); N.G. Walsh & T.J. Entwisle, *Fl. Victoria* 4: 118, Fig. 20g (1999).

**Fig. 7.** Type sheet of *Spyridium subochreatum* var. *laxiusculum* J.M.Black (AD98132267): **A** Keith, 23 Nov. 1917, [*J.M. Black s.n.*] (broad-leaved specimen); **B** Keith, 23 Nov. 1917, [*J.M. Black s.n.*] (small part of inflorescence); **C** Keith, 23 Nov. 1917, [*J.M. Black s.n.*] (narrow-leaved specimen); **D** Keith (cemetery), 23 Nov. 1917, [*J.M. Black s.n.*] (two narrow-leaved specimens, designated as the lectotype in this paper); **E** Wirrega, [1 Oct. 1916,] *T.G.B. Osborne s.n.* (several flowers and small part of inflorescence). Insets: Drawings of buds and flowers from specimen cover page.

***Distribution & habitat.*** One of the main components of dune-mallee and mallee-heath vegetation in north-western Victoria and south-eastern South Australia, usually in ± deep sand (white, brown or red). Also occurs in similar habitat on Yorke Peninsula and Eyre Peninsula in S.A., with a few records from around Toolinna in south-eastern W.A. on limestone-derived soils.

***Phenology.*** Flowers May–Dec.; fruits recorded in May, July, Sep.–Jan.

***Note.*** The species is very variable, e.g. the upper leaf surface can vary from glabrous to somewhat pubescent, to densely hairy. Specimens with a lax inflorescence and slightly smaller leaves were until recently recognised as var. *laxiusculum* (Canning & Jessop 1986; Barker *et al.* 2005). However, when examining specimens over the whole area of distribution, these characters grade into one another and distinct varieties cannot be recognised.

A recent molecular phylogeny of *Spyridium* (Clowes *et al.* 2022) showed one sample of *S. subochreatum* from W.A. to be separate from the remaining samples from eastern Australia in both cpDNA and nrDNA trees. The distinctness of this sample and other W.A. collections should be examined with molecular and morphological methods. In the meantime, however, *S. subochreatum* is recognised as one variable taxon for the *Flora of Australia* (Kellermann *et al.* 2022–).

***Conservation status.*** The species is not threatened in the eastern States, but listed as a Priority 2 taxon in W.A. (TSSC 2022).

***The identity of* Cryptandra pauciflora.** Rye (1996) only examined a photograph of the holotype of *C. pauciflora* and concluded that it belonged to the *Spyridium oligocephalum* group or to *S. spadiceum*. Examination of the specimen (and better-resolution images of KW001001110 and of duplicates at K and P, available online) clearly place it into synonymy with *S. subochreatum*: the specimen has large, fused stipules (*S. spadiceum* has free stipules), flowers covered in short hairs (*S. polycephalum* and *S. oligocephalum* have longer hairs) and leaves of the same size as recently collected W.A. specimens of *S. subochreatum*. While today, the taxon is only found near Toolinna on limestone, it seems to have been more widely distributed in W.A. in Drummond's time. The type was collected on his 5th collecting expedition, during which he also visited the Albany-Mt Barren-Ravensthorpe area, where there are several known limestone and lime sand deposits (Abeysinghe 1998).

***Typification of* Trymalium subochreatum *and* T. behrii.** Mueller (1855) described *T. subochreatum* from specimens collected in the "desert" (i.e. mallee vegetation) near the Murray River. In the protologue he stated that the leaves were "above scabrous or scantily velutinous". Reissek (1858) described plants that had a hairy upper leaf surface as *T. behrii* and restricted *Spyridium subochreatum* to specimens with glabrous (albeit rough or scabrous) leaves.

There are several specimens available at MEL and other institutions that were collected by Mueller near the Murray River. Some sheets are mixed specimens, containing two original labels and branches with both leaf variations (listed as "A" and "B"). A specimen with glabrous leaves is designated as the lectotype of *Trymalium subochreatum*.

While Reissek stated that the type of *T. behrii* was collected by Mueller, the epithet "*behrii*" indicated that the specimens had in fact been collected by Hans Hermann Behr. The only specimen with a collecting label by Behr and annotated with that epithet is designated as the lectotype of *T. behrii*.

***Typification of var.* laxiusculum.** When publishing *Spyridium subochreatum* var. *laxiusculum*, Black (1925) listed two localities in the protologue: Keith and Wirrega. His own herbarium at AD contains one copiously annotated sheet (AD98132267) with five collections (Fig. 7): (A) a broad-leaved specimen from "Keith"; (B) a small part of an inflorescence, collected in "Keith"; (C) a small twig from "Keith" with narrower leaves; (D) two branches from "Keith (cemetery)"; (E) some flowers and part of an inflorescence from "Wirrega", collected by T.G.B. Osborne. While A–D do not have a collector indicated, the collecting date for all of them is 23 Nov. 1917, the same date as two specimens in K and MEL, both of which have J.M. Black listed as collector (labelled in his own hand). We assume that all these specimens were collected by Black on the same day during a trip to Keith. His herbarium also contained a sheet with a collection by Osborne from Wirrega (AD97611498).

The two long branches from "Keith (cemetery)" on sheet AD98132267 (Fig. 7D), which have the glabrous leaves mentioned in the protologue, are selected as the lectotype, as they are the best-preserved branches of the specimens and come from Black's own herbarium.

***Etymology.*** From the Latin *sub-* (somewhat) and *ochrea* (a sheath round a stem formed by the cohesion of two or more stipules), on account of the large fused stipules of the species.

### *Selected specimens examined*

WESTERN AUSTRALIA [precise localities withheld for conservation reasons]. Toolinna Cove, 6 Sep. 2007, *E.D. Adams 21/0907* (CANB, PERTH); Toolinna Cove, SW Caiguna, 17 Oct. 1985, *G.J. Keighery & J.J. Alford 1043* (PERTH); Toolinna Cove, 26 Apr. 1988, *G.J. Keighery & J.J. Alford 1936* (PERTH); Toolinna Cove, 5 May 1992, *P.J. Spencer & A.S. George T1* (K, PERTH).

SOUTH AUSTRALIA. **Eyre Peninsula:** Hundred [Hd] of Dixson, c. 80 km NNE of Pt Lincoln, main Hwy, 18 May 1964, *C.R. Alcock 10A* (AD, MW, NY, US); 10 km E of Carapee Hill, 14 July 1993, *R. Bates 33561* (AD, CANB,

MA, RSA); W side of Coompana Water Res., 9 km W of Mangalo, then 3.4 km N on rd to Carpie Puntha Hill, then 1.5 km W on rd through res., 20 Oct. 1983, *J.D. Briggs 1399* (AD, CANB, MEL); Intersection of Bell / Broadbent / Hen and Chicken / Wilke Rds, 23 Oct. 2018, *J. Kellermann 760, 761 & F.J. Nge* (AD, K, MEL; AD, BM, NSW); 6.4 km direct ENE of Mt Bosanquet, Hd Jamieson, Sect. 22, 23 Oct. 1998, *S.D. Kenny & V.C. Hagan BS103-4158* (AD, B, KUN); N roadside of Rudall-Cleve rd, c. 500 m E of Ruddall on bend in rd, 6 Oct. 1995, *F. Udovicic 282* (AD, CANB, E, MEL, PERTH, SI); c. 25 km W of Pinkawillinie Hall, c. 2 km in ungrazed Crown Land, 11 Oct. 1981, *J.Z. Weber 7176* (AD, PE, TI, SIU). **Flinders Ranges:** Quorn School, Nov. 1926, *Anon.* [*Plant Survey of S.A., Field Naturalists' Section*] *2788* (AD); Mt Remarkable, 6 Sep. 1976, *R. Bates s.n.* (AD). **Northern Lofty:** Between Gawler and Mallala, 5 Sep. 1953, *J.B. Cleland s.n.* (AD); Scrub W of Hoyleton, 11 July 1884, *S. Dixon s.n.* (AD, ex Herb. Tate); Snowtown Rd near Bute, 15 Aug. 1967, *M.P. Hewton s.n.* (AD). **Murray:** 25 km E of Tailem Bend on Pinnaroo Rd, 3 Sep. 1985, *N.N. Donner 10630* (AD, AK, BRI, GZU, H, I, OSA, PTBG, UTEP, WRSL, WS); Chauncey's Line Res., c. 800 m N of Chauncey's Line on first ridge of white sand near the rd to Monarto South, 23 Sep. 1958, *H. Eichler 14956* (AD, B, L, M, NSW, PE, RSA, TAIF, UC, W); Karte Conservation Park (C.P.), 22 Aug. 1998, *T. Hall 473* (AD); Scorpion Springs C.P., 7 Oct. 1977, *E.N.S. Jackson 3526* (AD, SBSC, ZT); Monarto C.P., S part of loop tk, 1 Oct. 2018, *J. Kellermann 635* (AD, B, KW); Jim Jolly Rd, W of Billiatt, large dune on W side of rd, base of dune, 26 Aug. 2019, *J. Kellermann 785 & F.J. Nge* (AD, MO); Dog Lake Rd, Langhorne Creek, 27 Sep. 1998, *R.L. Taplin 821* (AD, MEL); Monarto C.P., 12 Oct. 1995, *F. Udovicic 323* (AD, CANB, MEL). **Yorke Peninsula:** c. 6 km SSE of Moonta, 23 Sep. 1967, *B.J. Blaylock 788* (AD, B, C, COLO); Sandhill c. 10 km N of Bute on Pt Broughton Rd, E side of rd, 8 May 1966, *B. Copley 269* (AD, CAL, E). **Southern Lofty:** c. 5 km S of Reeves Plains, 6 Aug. 1963, *N.N. Donner 813* (AD, G, NSW); Cox's Scrub Res., near Ashbourne, 16 Aug. 1970, *D. Hunt 3235* (AD, UC); 9 km E of Two Wells, Hd of Pt Gawler, Section 640, 5 Nov. 1997, *P.J. Lang BSOP-49* (AD, US, SI). **South Eastern:** Mt Rescue summit, [Ngarkat C.P.,] 10 Sep. 1985, *N.N. Donner 10773* (AD, GZU, HO, MA, MEL, SYD, TAI, TEX); Viewpoint on sand dune [c. 1 km] E of Carcuma C.P., 4 Sep. 1985, *E.N.S Jackson 5673* (AD, BISH, GH, LZ, MEL, W); Messent C.P., rd on S side of park, c. 3 km W of park corner, c. 50 m from rd, 29 Aug. 2019, *J. Kellermann 841 & F.J. Nge* (AD); Mt Shaugh C.P., 2 Oct. 1977, *D.E. Symon 10719* (AD, MO); Tauragat Hill on Coonalpyn-Lameroo rd, 14 km NE of Coonalpyn, on W side of rd, 12 Oct. 1995, *F. Udovicic 324* (AD, CANB, MEL, PERTH); Meningie, c. 10 km E on the rd to Coonalpin, 7 Jan. 1968, *J.Z. Weber 647* (AD, G, NSW); c. 25 km NW of Lucindale, 8 Oct. 1982, *J.Z. Weber 7416* (AD, PH, PRE, RSA); Desert Camp, between Keith & Naracoorte, 10 Oct. 1984, *D.J.E Whibley 9385* (AD, BAA, CHR, E, HO, NY, PERTH).

VICTORIA. Big Desert, 27.5 km S of Walpeup on rd to Patchewollock & 1–2 km S of Griggs junction, 1 Oct. 1980, *M.G. Corrick 6673, P.S. Short & B.A. Fuhrer* (AD, MEL); Little Desert N.P. near Dimboola, Desert Discovery Walk between starting point at River Tk (to Ackle Bend) and Eagle Swamp Tk, 28 Sep. 2017, *N.G. Karunajeewa 1598* (BRI, MEL); Big Desert, 30 m W of Murrayville-Nhill Rd, c. 16 km S of Murray Hwy, on top of large dune, 6 Oct. 2019, *J. Kellermann 919 & F. Nge* (AD, E); Nhill-Edenhope Rd, 13.4 km S from Hwy, W side of rd in remnant bushland, 7 Oct. 2019, *J. Kellermann 939 & F. Nge* (AD, B); Hattah-Kulkyne N.P., NW edge of Lendrook Plain, at end of tk 1.2 km from old Calder Hwy, 0.5 km past tk going off to S, Sep. 1986, *G.R. Lucas 239* (CANB, MEL); c. 13 miles N of Ouyen on Calder Hwy, 17 Aug. 1960, *T.B. Muir 1191* (AD, MEL); Wyperfeld N.P., Gunners Tk, c. 4 km S from N park boundary, 28 Nov. 2014, *R.W. Purdie 9653* (CANB, MEL); On S.A.-Vic. border, c. 12 [miles] SE of 'Bunns Springs' homestead, c. 14 miles (in direct line) due N of Adelaide-Melbourne Hwy, 28 Aug. 1959, *R.V. Smith 59/173* (CANB, MEL); McCrackens Rd, 9.1 km W of Murrawong Rd, c. 22.5 km NNW of Lillimur, 12 Oct. 2003, *N.G. Walsh 5858* (MEL).

### ***Spyridium villosum*** (Turcz.) Benth.

*Fl. Austral.* 1: 432 (1863). — *Cryptandra villosa* Turcz., *Bull. Soc. Imp. Naturalistes Moscou* 31(1): 458 (1858). — **Type citation:** "Nova Hollandia, Drum. V. n. 232." **Holotype:** Nova Hollandia, *J. Drummond 5: 232* ["*Drum: coll: V n 232*"] (KW001001111) (Fig. 8). **Isotypes:** West Australia, *J. Drummond coll. n. 232* (PH00022346, ex BM); West Australia, 1849, *5th collection, 232* (PERTH01671979, ex BM). W.A., *J. Dr.*[*ummond*] *232* (MEL705389); Swan River, *Drummond 232 5th coll.* (K000618740, ex Herb. Bentham); S. Australia, *Drummond 232* (K000618741, ex Herb. Hooker).

Evergreen low twiggy *shrubs*, 0.1–0.4 m high, without spines, young stems covered with dense grey stellate and sparse to medium dense flexuose rusty or brown simple hairs. *Leaves* alternate: *stipules* 1.8–3 (–5) mm long, triangular or ovate, apex acute or attenuate when young, free but overlapping near the base, moderately pubescent mostly along midrib; *petiole* 1–2.2 mm long; *lamina* narrowly elliptic or linear or oblong, 8–22 mm long, 1.5–2.5 (–6) mm wide, base obtuse, margins recurved, apex obtuse with a very short hairy mucro, tomentose with greyish dense very short simple and stellate hairs above, below densely white to greyish stellate-pubescent with fewer long simple hairs. *Inflorescences* comprising terminal or axillary heads, 5–8 mm long, 4–13 mm wide, with c. 8–30 flowers, with floral leaves covered in a dense white felty indumentum of stellate hairs; *bracts* ovate to orbicular, 1.4–2.5 mm long, sparsely pubescent in middle. *Flowers* 5-merous, bisexual, white or cream, with a dense grey stellate indumentum and longer flexuose spreading simple hairs; *pedicels* 1.2–4 mm long. *Hypanthium* cup-shaped with no apparent tube, c. 1 mm diameter. *Sepals* 1–1.2 mm long, widely spreading and almost recurved, with more hairs towards tip. *Petals* cucullate, 0.8–0.9 mm long, distinctly clawed. *Stamens* 0.6–0.8 mm long, incurved. *Disk* conspicuous, smooth, glabrous. *Ovary* almost inferior; roof pubescent with dense stellate hairs; *style* 0.4–0.5 mm long, glabrous. Mature *fruit* and *seeds* not seen; fruit body obovoid; torus in upper third.

**Fig. 8.** Holotype of *Cryptandra villosa* Turcz., current name *Spyridium villosum* (Turcz.) Benth. (KW001001111).

***Illustrations:*** B.L. Rye, *Nuytsia* 10: 130, Fig. 3E–H (1995); B.J. Grieve, *How to Know W. Austral. Wildfl. (2nd edn)* 2: 587 (1998).

***Distribution & habitat.*** Endemic to W.A., only known from the Stirling Range, growing in sand over sandstone in heathland and shrubland, with an atypical specimen recorded from Ongerup in sandy soil (Rye 1996).

***Phenology.*** Flowers May–Dec.; fruits recorded in May, July, Sep.–Jan.

***Note.*** The species is closely related to *S. spadiceum*, but differs in its linear to narrowly elliptic, densely hairy leaves (vs ovate leaves that become glabrous in *S. spadiceum*) and habitat on sandy soils over sandstone (vs granite).

***Conservation status.*** The species is listed as a Priority 2 taxon in W.A. (TSSC 2022).

***Etymology.*** From the Latin *villosus* (villous), on account of the species' densely hairy upper leaf surface.

***Selected specimens examined***

WESTERN AUSTRALIA [precise localities withheld for conservation reasons]. Donnelly Peak, Stirling Range N.P., 19 Oct. 2001, *S. Barrett 950* (PERTH); S of Pyungoorup, Stirling Range N.P., 5 Aug. 2008, *S. Barrett 1796* (PERTH); N of East Pillenorup Tk, Stirling Range N.P., 13 Sep. 2012, *S. Barrett 2130* (PERTH); Misery Hill, Stirling Range N.P., 11 Mar. 2014, *S. Barrett 2200* (PERTH); near Ongerup, 10 Oct. 1992, *E.J. Coxford 6644* (PERTH); Wedge Hill, Stirling Range, 4 Nov. 1987, *G.J. Keighery s.n.* (PERTH).

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# Updated nomenclature and an identification key for *Hibbertia* subg. *Pachynema* (Dilleniaceae), and description of a new species from the Northern Territory

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**Abstract:** The eleven species and three morphological species groups of *Hibbertia* subg. *Pachynema* (R.Br. ex DC.) J.W.Horn are discussed, and an identification key and the first formal synonymy for the subgenus are given. Additionally, the phrase name *Hibbertia* sp. Marrawal (*K.G. Brennan 3194*) from the Northern Territory is assessed, found to be distinct from all other species of *Hibbertia*, and formally described as *Hibbertia triquetra* T.Hammer.

**Keywords:** Dilleniaceae, *Hibbertia*, Northern Territory, *Pachynema*, taxonomy

## Introduction

*Hibbertia* Andrews is the largest genus in Dilleniaceae, with over 300 species currently accepted on the Australian Plant Census (APC 2022), 24 species in New Caledonia (one also in Fiji) and one species in Madagascar. A preliminary phylogeny by Horn (2009) resolved *Hibbertia* to be polyphyletic with respect to the genera *Adrastaea* DC. and *Pachynema* R.Br. ex DC. As a result, these two genera were synonymised under *Hibbertia*, and the four clades erected as the subgenera *Hibbertia* subg. *Adrastaea* (DC.) J.W.Horn, *Hibbertia* subg. *Hemistemma* (Juss. ex Thouars) J.W.Horn, *Hibbertia* subg. *Hibbertia* and *Hibbertia* subg. *Pachynema* (R.Br. ex DC.) J.W.Horn.

*Hibbertia* subg. *Pachynema* is a small group of species found in the Australian monsoonal tropics (i.e., in N.T. and W.A.) that are vegetatively distinct from the other subgenera. Mature plants of *H.* subg. *Pachynema* lack conspicuous leaves, having instead scale-like leaves along the stem that are similar in morphology to the floral bracts, leading some authors (e.g. Craven & Dunlop 1992; Horn 2009) to conclude that the entire flowering aerial shoot systems in *Pachynema* are inflorescences. Seedlings and resprouting plants have broad, basal leaves, but these are not persistent to maturity and are rarely found on herbarium specimens. Stems in *Pachynema* are cladodes, being the primary photosynthesizing organ; in some species the stems are distinctly flattened (e.g. *H. dilatata* (Benth.) J.W.Horn), while in others they are terete (e.g. *H. juncea* (Benth.) J.W.Horn).

Craven & Dunlop (1992) revised *Pachynema* and included seven species, three of which were newly described. They excluded *H. conspicua* (J.Drumm. ex Harv.) Gilg and *H. goyderi* F.Muell. from their concept of the genus, despite these species having the *Pachynema* vegetative morphology; they differ from *Pachynema* species mainly by having flowers with yellow petals (*vs.* white, pink or red) and stamens with more or less strap-like staminal filaments and elongate anthers (*vs.* short and bulbous filaments with minute anthers). The floral morphology of *H. conspicua* and *H. goyderi* is broadly similar to the leafy *Hibbertia* species, especially the eastern Australian *H. salicifolia* (DC.) F.Muell. (previously treated as the monotypic genus *Adrastaea* DC.). *Hibbertia goyderi* was placed from its inception within *Hibbertia*, while *H. conspicua* was originally described in a monotypic genus *Huttia* J.Drumm. ex Harv. before being transferred to *Pachynema* sect. *Huttia* (J.Drumm. ex Harv.) Benth. & Hook.f. as the sole species, and then subsequently to *Hibbertia* sect. *Huttia* (J.Drumm. ex Harv.) F.Muell.

A partial phylogeny of *Hibbertia* and its close relatives by Horn (2009), based on chloroplast sequences, included three *Pachynema* species (*P. dilatatum* Benth., *P. junceum* Benth. and *P. sphenandrum* F.Muell. & Tate) and resolved these as a clade with *H. conspicua* and *H. goyderi*. Horn (2009) formally combined *Pachynema* under *Hibbertia* by making the new combination *H.* subg. *Pachynema*, expanding the subgenus to include *H. conspicua* and *H. goyderi*. While the texts of his paper (Horn 2009) and PhD thesis (Horn 2005) make it clear that he intended to include *H. conspicua* and *H. goyderi* within *H.* subg. *Pachynema*, the treatment


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**Table 1.** Morphological species groups of *Hibbertia* subg. *Pachynema* and their members.

| ***H. complanata* group** | ***H. sphenandra* group** | ***H. conspicua* group** | **Uncertain placement** |
|---|---|---|---|
| *H. complanata* | *H. haplostemona* | *H. conspicua* | *H. paranthera* |
| *H. cravenii* | *H. praestans* | *H. goyderi* | |
| *H. dilatata* | *H. sphenandra* | *H. triquetra* | |
| *H. juncea* | | | |

of Horn (2009) included no list of species included in each subgenus, nor did he formally assign previous genera and infrageneric taxa as synonyms (see also Kellermann *et al.* 2022).

A specimen of an unknown *Hibbertia* was collected by K.G. Brennan from the Marrawal Plateau, N.T., in 1996 and subsequently given the phrase name *H.* sp. Marrawal (*K.G. Brennan 3194*) in the Northern Territory (Cowie & Albrecht 2005). It was recognised to be similar to, but different from, *H. goyderi*, placing it within the current concept of *H.* subg. *Pachynema*. As part of a treatment of all species of *Hibbertia* being prepared for the *Flora of Australia*, I here critically evaluate the status of *H.* sp. Marrawal (*K.G. Brennan 3194*) (subsequently referred to as *H.* sp. Marrawal), compare it to all other species in the subgenus, and describe it as new. An identification key and formal list of synonyms for *H.* subg. *Pachynema* are provided.

## Methods

This study was conducted by examining herbarium specimens and spirit material at AD and on loan from DNA.

## Discussion

### Affinities within subg. *Pachynema*

There are three main species morpho-groups within *Hibbertia* subg. *Pachynema* that can be readily segregated based on floral morphology (Table 1). These are the *H. complanata* (R.Br. ex DC.) J.W.Horn group, the *H. sphenandra* (F.Muell. & Tate) J.W.Horn group, and the *H. conspicua* group. Species in the *H. complanata* group (*H. complanata* (R.Br. ex DC.) J.W.Horn, *H. juncea*, *H. dilatata* and *H. cravenii* J.W.Horn) have white to pink, caducous petals; they differ from each other mainly by the presence and position of staminodes, stem shape in cross-section (flat or terete), and whether or not the stems are dimorphic. Species in the *H. sphenandra* group (*H. sphenandra*, *H. praestans* (Craven & Dunlop) J.W.Horn and *H. haplostemona* J.W.Horn) have dark red petals that are more or less persistent to the fruiting stage. Petals in *H. sphenandra* may be caducous, but this species can be otherwise discriminated by having an irregularly lobed, membranous sheath that encircles the androecium, referred to by previous authors as a 'corona' (e.g. Craven & Dunlop 1992); it is the only known *Hibbertia* species with such a structure and requires more study

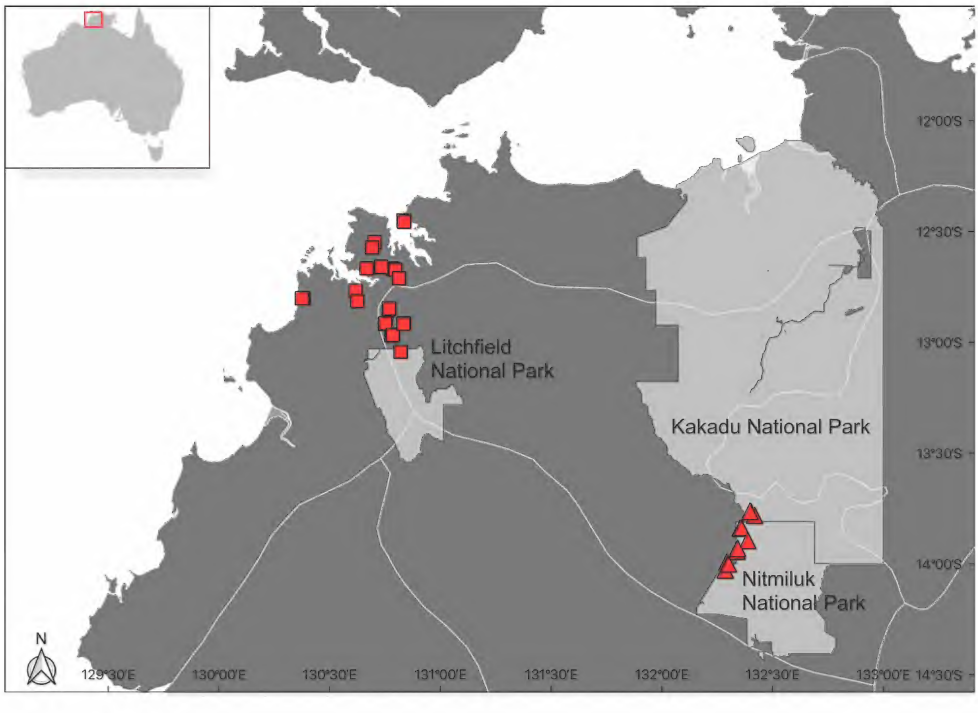


**Fig. 1.** Map of occurrences of *H. triquetra* (red triangles) and H. *goyderi* (red squares). Light grey shaded regions are national parks. White boundaries are IBRA 7.0 regions (DAWE 2022).

as to its origin. The *H. conspicua* group (*H. conspicua*, *H. goyderi*, *H.* sp. Marrawal) have yellow, caducous petals, flattened staminal filaments, elongate anthers, and staminodes (when present) in a whorl outside the two fertile staminal whorls.

The unusual species *Hibbertia paranthera* K.R.Thiele (Thiele 2015) has a combination of morphological characters that makes it difficult to place within any one of these traditional groups. The species has pink, caducous petals that are similar to those of the *H. complanata* group, but one whorl of two stamens that have flattened filaments and anthers 2–2.5 mm long. The androecium in the *H. complanata* group has two whorls of stamens (an outer of 7–10 stamens, and an inner of 2 stamens or staminodes) that have rounded, bulbous filaments and anthers usually 0.3–0.5 mm long. A forthcoming molecular phylogeny of the genus by T. Hammer *et al.* (in prep.) may resolve the relationships of this interesting species.

### *Hibbertia* sp. Marrawal

*Hibbertia* sp. Marrawal is considered here to be a member of *H.* subgen. *Pachynema* based on its morphological similarity to *H. goyderi* and *H. conspicua*. It is only known from the Marrawal Plateau in Arnhem Land and is geographically widely disjunct from *H. goyderi*, which occurs from the vicinity of Darwin to Litchfield National Park (N.P.) and west to near Dundee Beach (Fig. 1).

*Hibbertia goyderi* shares with *H.* sp. Marrawal the unusual morphology of triquetrous (three-angled) stems. The stems of *H.* sp. Marrawal are more noticeably triquetrous due to the three sides of stems being typically smoother and less wrinkled or striated than those of *H. goyderi*, at least in dried specimens. The only other species with a distinctly triquetrous stem is the Western Australian *H. paranthera* K.R.Thiele, but this species can be readily differentiated from *H.* sp. Marrawal and *H. goyderi* by having flowers with pink petals, two stamens and lacking staminodes. *Hibbertia*

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### Key to *Hibbertia* subg. *Pachynema*

**1.** Petals white, pink or red; staminodes, if present, 2, internal to the fertile stamens
- **2.** Petals white to pink, caducous; corona absent
  - **3.** Stems triquetrous; androecium comprising 1 whorl of 2 stamens; Kimberley, W.A. . . . . *Hibbertia paranthera*
  - **3:** Stems terete to flattened; androecium comprising 2 whorls, the outer whorl with 7–10 stamens, the inner whorl with 2 stamens or staminodes; N.T. (*H. complanata* group)
    - **4.** Stamens of inner whorl fertile; staminal filaments smooth to sub-papillate; anthers (0.8–) 1–1.8 mm long . . . . . *Hibbertia cravenii*
    - **4:** Stamens of inner whorl infertile (staminodes); staminal filaments papillate; anthers 0.3–0.5 (–0.7) mm long
      - **5.** All branchlets terete to slightly compressed . . . . . *Hibbertia juncea*
      - **5:** All branchlets distinctly broad and flattened, or branchlets dimorphic with shorter stems flattened and branchlets of taller stems terete to flattened
        - **6.** Stems dimorphic, the shorter stems with branchlets 3–10 (–15) mm wide and the taller stems with terete to flattened branchlets distinctly narrower than those of the shorter stems . . . . . *Hibbertia complanata*
        - **6:** Stems not dimorphic, the branchlets 5–20 (–35) mm wide . . . . . *Hibbertia dilatata*
- **2:** Petals red, persistent, or if caducous then corona present (*H. sphenandra* group)
  - **7.** Corona around androecium present; stamens 7 or 9, in two whorls; N.T., W.A. . . . . *Hibbertia sphenandra*
  - **7:** Corona around androecium absent; stamens 4 or 5, in one whorl; N.T.
    - **8.** Prostrate to decumbent shrubs to 0.3 m high; branchlets ± straight; stamens 5, the filaments gibbous . . . . . *Hibbertia haplostemona*
    - **8:** Shrubs 1.5–2 m high; branchlets ± drooping; stamens 4 (5), the filaments ± flattened . . . . . *Hibbertia praestans*

**1:** Petals yellow; staminodes, if present, several in a whorl outside the fertile stamens (*H. conspicua* group)
- **9.** Stems ± terete; sepals pubescent (the outer ones rarely glabrous) with straight and hooked simple hairs; staminodes absent or c. 0.8 mm long; south-west W.A. . . . . *Hibbertia conspicua*
- **9:** Stems triquetrous; sepals glabrous; stamens surrounded by a whorl of staminodes 1.5–2 mm long; N.T.
  - **10.** Flowers solitary on stems, terminal, sessile or indistinctly pedicellate; inner sepals acute to acuminate . . . . . *Hibbertia goyderi*
  - **10:** Flowers few to several per stem, axillary, distinctly pedicellate; inner sepals obtuse to rounded . . . . . ***Hibbertia triquetra***

DNA
Hibbertia triquetra T.Hammer
Holotype
Det./Conf.:T.A. Hammer 15 July 2022
Hibbertia sp. D 137990 Marrawal
Kym. Brennan 15 Oct 01
NORTHERN TERRITORY HERBARIUM
DARWIN (DNA) AUSTRALIA
Pachynema hooglandii Craven & Dunlop
4 km SW Bloomfield Springs, Kakadu National Park.
STATE/DIST.: NT / DG 13°47'00"S 132°25'00"E
Common shrubs on edge of Allosyncarpia forest in sandstone; corollas yellow.
Russell-Smith, J. & Lucas, D. 9109 05 Jan 1995
DILLENIACEAE
BRLCANB,DNA
D0137319
cm 0 1 2 3 4 5 6 7 8 9 10
copyright reserved
State Herbarium of South Australia
AD

**Fig. 2.** Holotype of *Hibbertia triquetra* (DNA D0137319).

State Herbarium of South Australia
AD169293
AD169053
Hibbertia goyderi F.Muell.
Det./Conf.:T.A. Hammer 14 July 2022
EX NORTHERN TERRITORY HERBARIUM
DARWIN (DNA) AUSTRALIA
Hibbertia goyderi F.Muell.
Wangi Rd; c 1 km S of Finniss River Crossing
STATE/DIST.: NT / DG 12°58'09"S 130°46'40"E
multi stemmed perennial subshrub resprouting after early dry season fire; corolla yellow; in E miniata open woodland with Acacia difficilis, Melaleuca nervosa on sandy soil
Cowie, I.D. & Cowie, L.J. 9799 02 Jul 2003
DILLENIACEAE
AD BRI DNA MEL
D0158560
cm 0 1 2 3 4 5 6 7 8 9 10
copyright reserved
State Herbarium of South Australia
AD

**Fig. 3.** Representative specimen of *Hibbertia goyderi* (AD169293).

sp. Marrawal and *H. goyderi* have yellow petals, a whorl of staminodes outside of the stamens, and 8 or 9, or 8–10 stamens, respectively.

*Hibbertia* sp. Marrawal and *H. goyderi* can be additionally differentiated by the shape of the sepal apex and the number and arrangement of flowers on the main stems (Figs. 2 & 3). *Hibbertia* sp. Marrawal has multiple (up to c. 12), seemingly axillary flowers per stem borne on pedicels that are thinner and much shorter than the stems and of a different shape, being ± compressed-terete (often irregularly striate) and 0.3–0.5 mm wide, while the stems are c. 1–2.5 mm wide (Fig. 2, Fig. 4A). In contrast, flowers in *H. goyderi* are usually solitary, terminal and sessile on the triquetrous stems (Fig. 3), or are occasionally borne on short, triquetrous lateral stems, but lack distinct pedicels. *Hibbertia* sp. Marrawal can be additionally differentiated by having obtuse inner sepals (Fig. 4A, B), the inner and outer sepals of *H. goyderi* being distinctly acute to acuminate (Fig. 4C, D).

*Hibbertia conspicua* is the only species in *H.* subg. *Pachynema* that occurs outside of tropical Australia, being endemic in south-west Western Australia. Despite this geographic disjunction, it is morphologically quite similar to *H.* sp. Marrawal and *H. goyderi*. *Hibbertia conspicua* can be readily distinguished from these two species by having terete stems, pubescent young stems and leaves with mostly retrorse hooked hairs, and having pedicellate flowers well-separated in poorly defined inflorescences. Staminodes in *H. conspicua* are minute or lacking, in contrast to the long and distinct staminodes in *H. goyderi* and *H.* sp. Marrawal.

*Hibbertia* sp. Marrawal can be readily distinguished from all other members in the genus, and is formally described below as *Hibbertia triquetra* T.Hammer.

## Taxonomy

### *Hibbertia* subg. *Pachynema* (R.Br. ex DC.) J.W.Horn

*Int. J. Pl. Sci.* 170(6): 809 (2009). — *Pachynema* R.Br. ex DC., *Syst. Nat.* 1: 397, 411–412 (1817). — *Pachynema* R.Br. ex DC. sect. *Pachynema*: Benth. & Hook.f., *Gen. Pl.* 1(1): 15 (1862). — **Type:** *Pachynema complanatum* R.Br. ex DC. [≡ *Hibbertia complanata* (R.Br. ex DC.) J.W.Horn].

*Pachynema* sect. *Stemmatanthus* F.Muell. & Tate, *Trans. Proc. & Rep. Roy. Soc. South Australia* 5: 79 (1882). — *Pachynema* sect. *Stematanthus* Gilg & Werderm. in Engler & Prantl, *Nat. Pflanzenfam.* ed. 2, 21: 30 (1925), *orth. var.* — **Type:** *Pachynema sphenandrum* F.Muell. & Tate [≡ *Hibbertia sphenandra* (F.Muell. & Tate) J.W.Horn].

*Huttia* J.Drumm. ex Harv. in Hooker, *Hooker's J. Bot. Kew Gard. Misc.* 7: 51 (1855). — *Pachynema* sect. *Huttia* (J.Drumm. ex Harv.) Benth. & Hook.f., *Gen. Pl.* 1(1): 15 (1862). — *Hibbertia* sect. *Huttia* (J.Drumm. ex Harv.) F.Muell., *Fragm.* 7(56): 123 (1871). — **Type:** *Huttia conspicua* J.Drumm. ex Harv. [≡ *Hibbertia conspicua* (J.Drumm. ex Harv.) Gilg].

### *Hibbertia triquetra* T.Hammer, *sp. nov.*

**Holotypus:** 4 km SW [of] Bloomfield Springs, Kakadu National Park, Northern Territory, 5 Jan. 1995, *J. Russell-Smith & D. Lucas 9109* (DNA D0137319!). **Isotypi:** CANB, BRI; both *n.v.*

*Hibbertia* sp. Marrawal (*K.G. Brennan 3194*) Northern Territory Herbarium, R.A.Kerrigan & Albr., *Checkl. N. Terr. Vasc. Pl. Sp.* [not paginated] (2007).

Erect or rounded *shrubs* 0.3–1.2 m high, multi-stemmed, resprouting from a woody rootstock. *Stems* triquetrous, the sides ± smooth except for minute papillae, often slightly glossy, green (becoming glaucous with age), glabrous; older stems becoming woody and more rounded towards the base. *Cauline leaves* scale-like, narrowly triangular, 2–3 mm long, caducous with usually the tip or all but the very base falling away, glabrous; apex acute to attenuate. *Seedling and resprout leaves* not seen. *Flowers* single, along stems at inconspicuous nodes, each subtended by a scale-like leaf, pedicellate; pedicel 1–2.5 mm long, 0.3–0.5 mm wide, distinctly narrower than the stems, ± compressed-terete, glabrous; bracts 2–4, subtending or recaulescent on the pedicel, 1–1.5 mm long, similar to but usually smaller than the subtending scale-like leaf, glabrous. *Sepals* unequal, glabrous; outer sepals 2, ovate to elliptic, 4–5 mm long, narrowly scarious-margined, the apex acute to obtuse and apiculate; inner sepals 3, elliptic to broadly elliptic, 6–7 mm long, broadly scarious-margined, the apex obtuse to rounded and entire to emarginate. *Petals* 5, yellow, broadly obovate to spathulate, 5–7 mm long, emarginate. *Stamens* 8 or 9, arranged in two tight whorls in a cone-like structure around the gynoecium at anthesis (later diverging), the outer whorl with 6 or 7 stamens, the inner whorl with 2 stamens that are tucked between the carpels; filaments ± flattened, connate basally, 1–1.2 mm long (fused plus free portion); anthers lanceolate, 2–2.5 mm long, dehiscing by introrse, longitudinal slits; staminodes 8–16, ± linear, 1.5–2 mm long, outside the stamens, erect to radiating outward. *Carpels* 2; ovaries compressed-ovoid to -globular, ± smooth, glabrous, 2-ovulate; styles robust, subulate, 3–3.5 mm long, erect and enclosed by the anthers (at anthesis) with the stigmas placed above them. *Seeds* ± globular, 3.2–3.8 mm long, brown, shiny, reticulate; aril ± membranous, slightly fleshy basally, covering basal one-third to one-half of seed. **Figs 2, 4A, B.**

***Diagnostic features.*** *Hibbertia triquetra* can be readily distinguished from all other species of *Hibbertia* by the combination of its stems being triquetrous and having the cauline leaves very reduced and narrowly triangular to 3 mm long, multiple flowers along the stems that are distinctly pedicellate, obtuse inner sepals, yellow petals, 8–16 linear staminodes arranged around the fertile stamens, and 8 or 9 fertile stamens arranged around two glabrous, ± smooth carpels.

**Fig. 4.** *Hibbertia triquetra*: **A** flower bud and pedicel; **B** open flower (corolla). *Hibbertia goyderi*: **C** closed flower; **D** open flower. — **A, B** DNA D0137319; **C, D** AD169293.

***Phenology.*** Recorded as flowering January–May and fruiting March–May.

***Distribution.*** Occurs from the Marrawal Plateau (*K. Brennan 7495*) in the southwestern corner of Kakadu N.P. to upper Fergusson River area (*I.D. Cowie & A. Gibbons 9527*) in western Nitmiluk N.P., apparently restricted to the Pine Creek IBRA region (Fig. 1).

***Habitat.*** Occurs on plateaus, ridges, slopes or near creeks in open *Corymbia dichromophloia* woodlands or on the edge of *Allosyncarpia* forests, on laterite, quartzite or sandstone.

***Conservation status.*** Not conservation listed. Conserved in Kakadu and Nitmiluk national parks.

***Etymology.*** From the Latin *triquetrus* (triangular, having three corners), referring to the shape of the stem in cross section.

***Notes.*** Other members of *H.* subg. *Pachynema* that overlap with or occur near *H. triquetra* can be readily differentiated. *Hibbertia juncea* (Benth.) J.W.Horn is recorded from the Marrawal Plateau and nearby areas in Kakadu and Nitmiluk national parks. It has ± terete stems, white or pinkish petals, and two androecial whorls, the outer comprising fertile stamens with round and papillate staminal filaments and very reduced anthers, and the inner whorl comprising two staminodes. *Hibbertia dilatata* and *H. complanata* have white to pink petals and at least some stems distinctly flattened. *Hibbertia triquetra* can be differentiated from these species by having triquetrous stems, yellow petals, and an androecium of two whorls of fertile stamens, usually tightly appressed in a conical structure, with the anthers approximately twice the size of the flattened filaments and with a whorl of thread-like staminodes surrounding the fertile stamens.

*Hibbertia sphenandra* is not recorded at the same localities as *H. triquetra*, but there are records nearby in Kakadu N.P., Nitmiluk N.P. and near Pine Creek. It differs in having ± terete stems (*vs.* triquetrous stems) and red flowers with usually persistent petals (*vs.* yellow, caducous petals), a persistent membranous corona around the androecium (*vs.* lacking such a structure), and stamens with thickened and angular staminal filaments (*vs.* filaments ± flattened).

***Additional specimens examined.***

NORTHERN TERRITORY. Marrawal Plateau, S of Bloomfield Springs, 6 Feb. 1996, *K. Brennan 3194* (DNA); Marrawal Plateau, Kakadu N.P., 15 Mar. 2008, *K.G. Brennan 7495* (DNA); Nitmiluk N.P., upper Fergusson River area, 25 Mar. 2002, *I.D. Cowie & A.K. Gibbons 9527* (AD; DNA, *n.v.*); 20 km N Edith Falls, Nitmiluk N.P., 25 Mar. 2002, *C.R. Michell 3926* (DNA; MO, *n.v.*); N Edith Falls, Nitmiluk N.P., 25 Mar. 2002, *C.R. Michell 3927* (DNA); Site 608, Nitmiluk N.P., 22 May 2001, *J.A. Risler & B. Deichmann 1545* (DNA).

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